

The Blast Furnace and Steel Plant

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The Blast Furnace *and* Steel Plant

VOL. VII.

PITTSBURGH, PA., NOVEMBER, 1919.

No. 11

Allis-Chalmers Heavy Forging Plant

Allis-Chalmers Forge Shop Equipped With 3,000-Ton Hydraulic Press, 1,000-Ton Press and Series of Hammers—Plant Built With Future Expansion in View.

SOME 12 years ago the Allis Chalmers Manufacturing Company, of Milwaukee, in their development of their large units for steam, electric and hydraulic plants were face to face with the necessity of either going to the large forging plants in the East (or even to Krupps) for the large forgings required, which would necessitate delay and inconvenience as well as interfering very materially with deliveries; or spending a large sum of money and putting in a forge plant large enough to take care of heavy forge work. The management decided on the latter course, immediately planning a new forge shop and designing it to take care of some future expansion by installing a 2,500 (afterward enlarged to 3,000 tons) hydraulic press of the steam intensifier type. Later a 1,000 ton press and a series of various sized hammers were added. This gave more capacity than was required for the needs of the company and consequently the Allis Chalmers Company went into the market to sell heavy forgings, either rough forged, rough machined or finish machined.

On the 3,000 ton press, forgings can be made up to 40 tons weight, from ingots weighing 55 to 60 tons for the reason that the upper 20 to 30 per cent of the ingot must be discarded on account of being piped, due to shrinkage in cooling. Within this weight, the plant is equipped to forge, heat treat and machine shafts up to 60 feet long, or up to 48 inches in diameter.

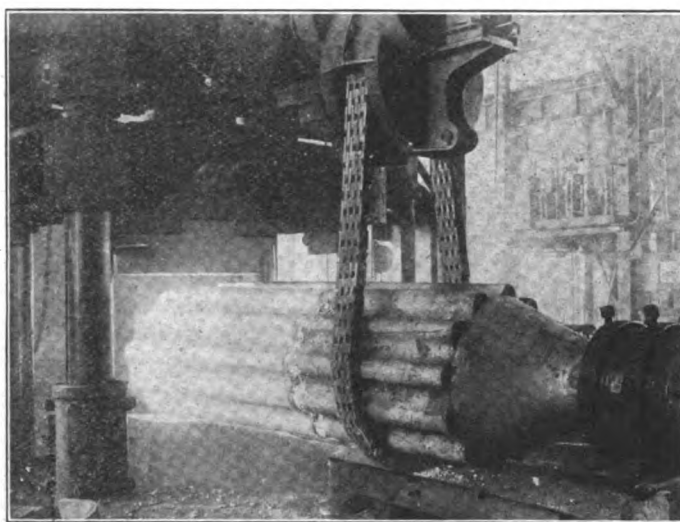
The press was built by the Niles-Bement-Pond Company, and is of the steam intensifier type, the intensifier being furnished by the United Engineering & Foundry Co., and is capable of forging ingots up to 66 inches in diameter, within the limits set forth above. The press

is served by two Niles cranes, one on each side of the press running at right angles to the length of the shop, one of 75 tons capacity, the other 40 tons. Under the big crane are placed two single door furnaces with capacity to take the largest ingots which the shop can handle. Four double door furnaces capable of taking ingots up to 48 inches in diameter, giving 10 door openings to serve the press are served by the 40 ton crane. These furnaces are all of the oil fired regenerative type, most of them being the new back fired Stevens furnaces.

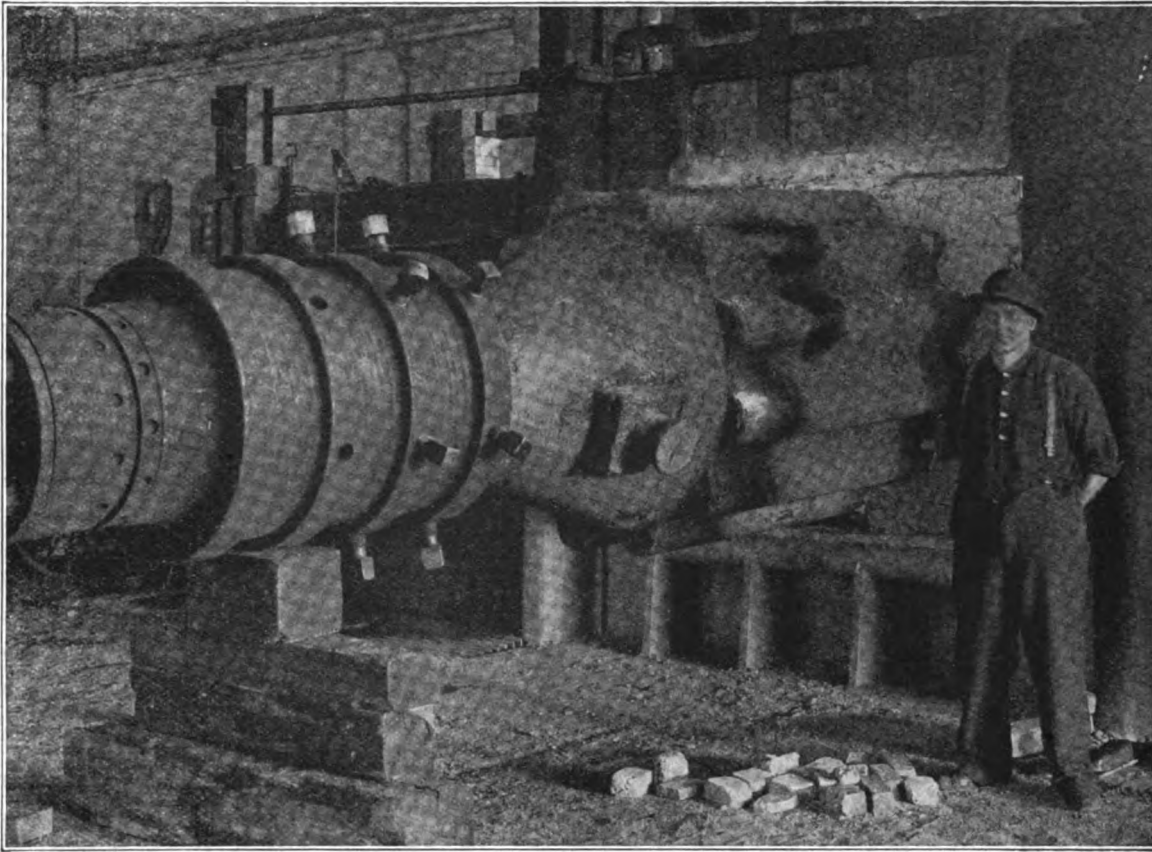
For rotating and manipulating the ingots a 75 ton and a 50-ton turning rig manufactured by the J. C. Busch Company, of Milwaukee, is used. Two hydraulic drawbacks or carriers, one on each side of the press carry the ingots or forgings backward or forward under the press while forging. The carriers can also be hooked up to the anvil or lower die block and the die drawn out on either side of press for making changes, or turning over rings, nuts or other short forgings.

Gun forgings, jackets, tube liners, torpedo cylinders and pistons for large navy guns, shafting for

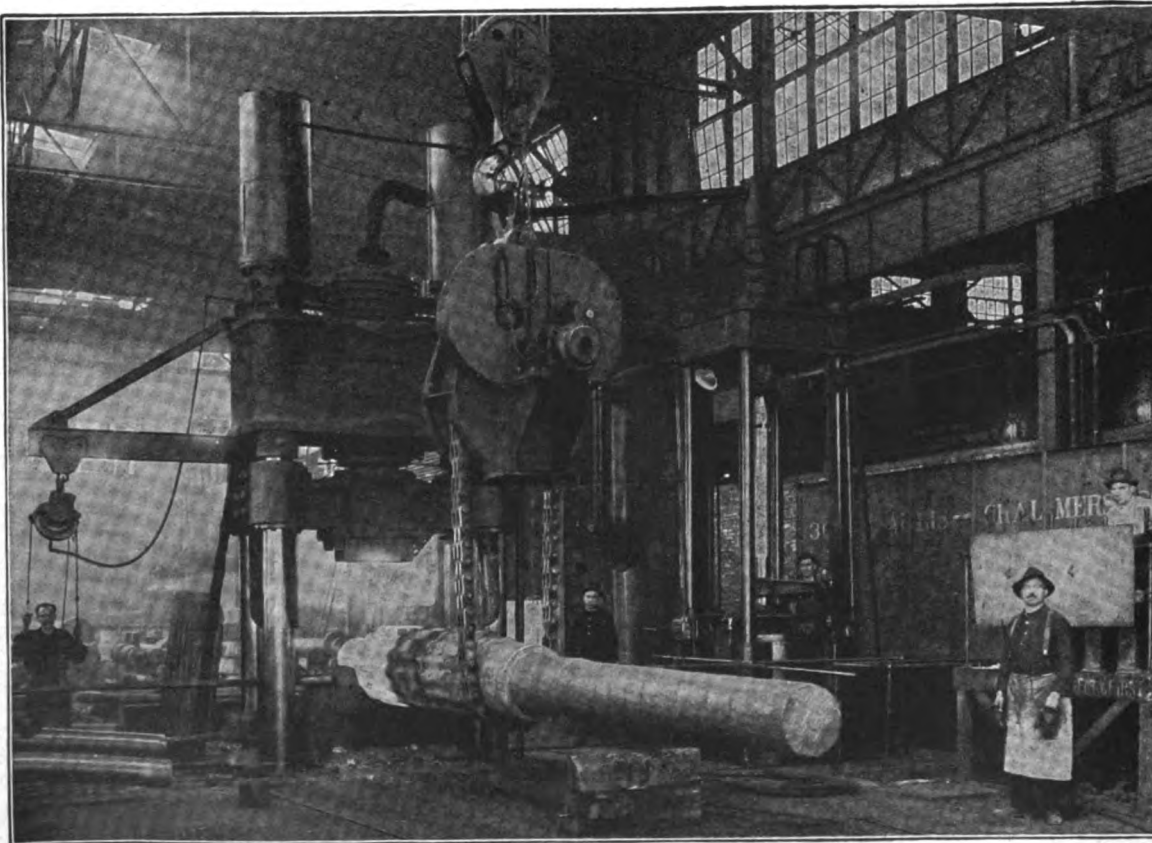
battle ships, cruisers and destroyers, connecting rods, rudder stocks, etc., rotor shafts, steam and hydraulic turbine shafts and discs, crusher shafts, shaft connecting rods, etc., for gas and oil engines, are among the products made on this press. A 1,000-ton United Engineering & Foundry Co. steam intensifier type hydraulic press was built and installed expressly for war orders. The press is fed by three two-door Stevens new type back fired regenerative furnaces and is served by a 20-ton Pawling & Harnishfeger crane, equipped with a 20-ton J. C. Busch electric turning rig. The press is



Hydraulic press in Allis-Chalmers forge shop.



Large ingot being heated.



Small hydraulic forge press.

equipped with water cooled top and bottom dies.

The shop is also equipped with a six-ton Chambersburg double frame steam hammer with two double door furnaces, one of them a Stevens back fired regenerative type. A 20-ton Niles crane with J. C. Busch turning rig serves this hammer. There is also a Morgan double frame steam hammer served by two double door furnaces, one of which is a Stevens furnace. A 20-ton P. & H. crane with a 10-ton Busch turning rig serves this hammer. A 3,500-pound Niles steam hammer and a 3,500-pound Chambersburg are each equipped with double door oil-fired furnaces and served by Northern electric jib cranes. For the smaller work there are three 2,500-pound hammers, one Niles and two Chambersburg, each equipped with oil-fired double door furnaces and jib cranes with hand-operated hoists.

To satisfy the requirements of the engineering department it was necessary to build a heat treating plant. This department contains three car type box furnaces 8 x 12 x 16 feet, two car-type furnaces 6 x 8 x 30 feet, two car type furnaces 6 x 8 x 45 feet, one

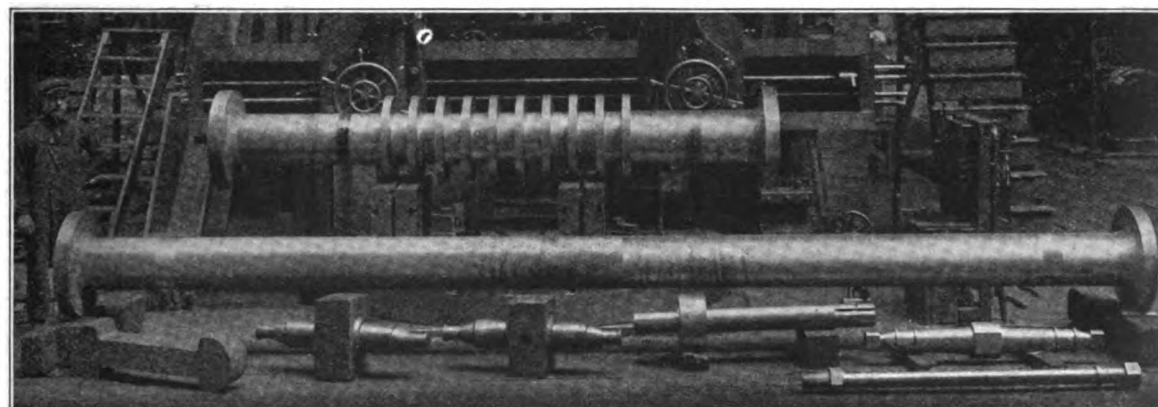
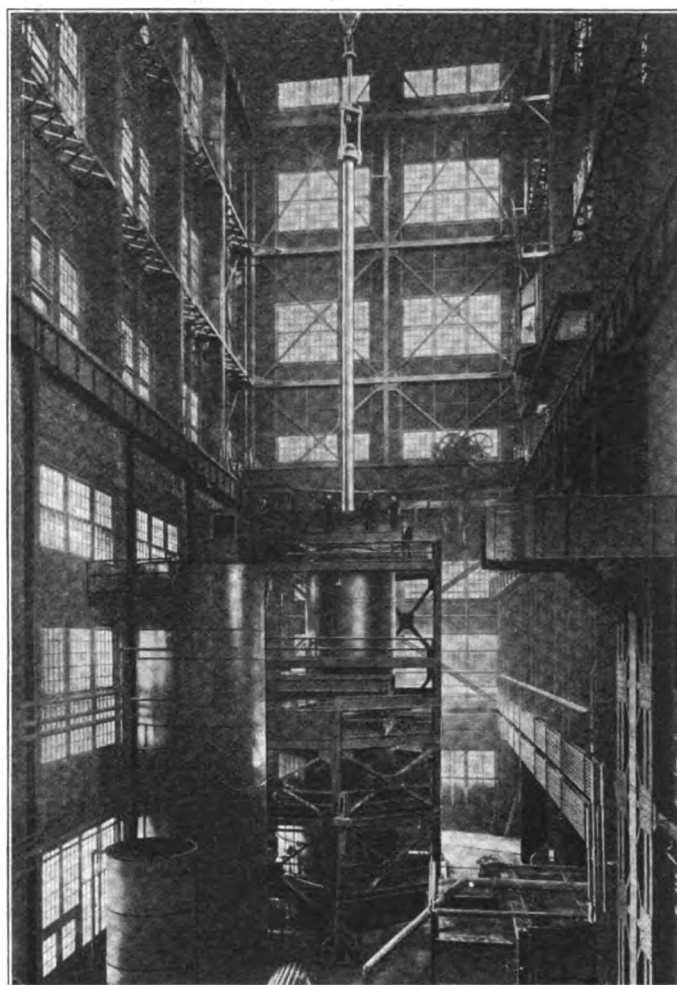
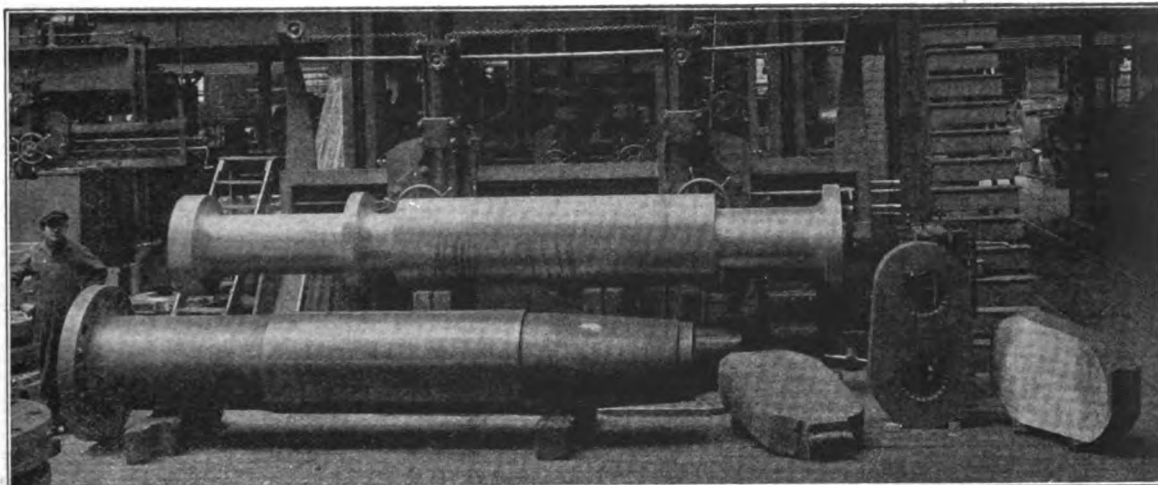
car type furnace 6 x 8 x 50 feet, one open top furnace 5 x 7 x 16 feet, and one open top furnace 6 x 8 x 50 feet, used for pre-heating and annealing, and many others of smaller dimensions.

All of these horizontal furnaces are of the semi-muffle car type. For the heat treatment of the hollow shafts there are two large semi-muffle vertical furnaces, one being 14 feet in diameter by 70 feet high, for treating shafts up to 60 feet long, the other being the same diameter and 50 feet high. These vertical furnaces are set in a concrete pit, the floor of which is 25 feet below the level of the shop floor. The crane to handle these long shafts is an Alliance 30-ton crane, on rails 135 feet above the floor. It is fitted with a special quick release, so that a forging can be lowered into the quenching tank at a speed of 175 feet a minute. This crane has a remote control located slightly above the height of the furnaces and quenching tank, and midway between the furnaces and quenching tank, so that the operator can easily see all movements. To aid him in locating the center of the tank with a hot shaft, the crane has signal lights that show only when the hook is central over the quenching tank. The large vertical quenching tank is 14 feet in diameter by 75 feet deep, set conveniently close to the furnaces. Being 35 feet in the ground the top is at approximately the same level as the top of the furnaces, so that the forgings when hoisted out can be swung directly over the tanks and lowered. The crane man has telephone connections to the upper, middle and lower levels of the furnace. There are also two smaller vertical tanks, one 10 x 30 feet deep and the other 6 x 15 feet deep.

A 6 x 6 x 45 foot horizontal quenching tank is provided with high pressure water inlets on one side and large outlets on the opposite side, to eliminate the heated water quickly.

The vertical furnaces are of a new design developed during the war period. The vertical furnace proper is 69 feet 9½ inches high, without cover, and 14 feet, ¾ inch in diameter outside the steel casing. The interior of the furnace is lined first with 2½ Sil-O-Cel insulating brick next the casing,

The center illustration shows a view of the vertical heating furnace which is 70 feet high and 14 feet outside diameter. The top and bottom illustrations show some of the work turned out by Allis-Chalmers company.



then 18 inches of second quality fire brick with $4\frac{1}{2}$ -inch facing of best quality fire brick, then a $4\frac{1}{2}$ -inch heating space, next to which there is a $4\frac{1}{2}$ inch perforated baffle wall. This section runs the full height of furnace with supports for the flue chambers spaced at $4\frac{1}{4}$ inch intervals. The inside diameter of the furnace inside the brick work is 8 feet 4 inches.

The oil burners are arranged with outside combustion chamber, chamber and burner set tangentially to the wall of the furnace with full spread both ways to allow for free expansion of gases. There are four burners on a line to the circle, and there are eight working levels with two sets of four burners to each level, except the top level, which has one set of burners. The perforations are evenly spaced up and down but of different dimensions on the circle so as to maintain an even gas pressure according to the distance from the burners.

The cover is divided into halves set on wheels, which run on a rail supported on separate steel work and which are connected with a chain belt so that the halves can be quickly drawn in opposite directions. For supporting the forgings in the furnace a crab is placed over the end of the forging (on which a collar has been left in forging or turning) and a hinged pawl or wedge fitting between the diameter of the forging in the crab. The upper part of the crab shaft has a large collar and eye with plenty of clearance for the crane hook. The crab with the forging hung in it is lowered

into the furnace and suspended on two heavy eye beams on wheels which are brought together under the collar of the crab. These eye beams are supported on a heavy steel structure outside of the furnace proper. The half covers are then closed and the heat turned on.

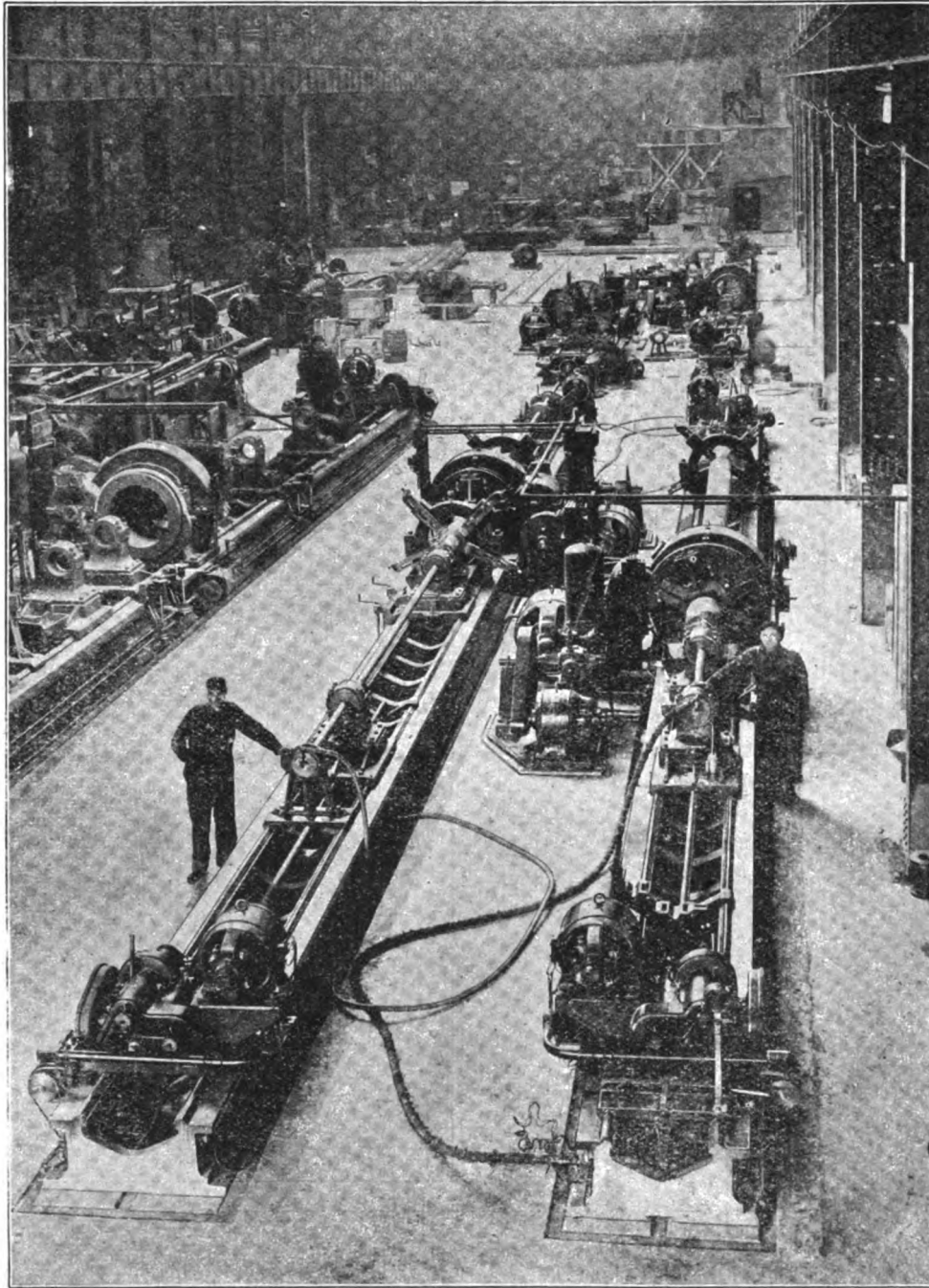
An automatic electric elevator connects all the levels so that the furnace tender can readily get to various levels without climbing stairs.

There are 120 burners on this furnace. Should a leak develop in the oil line anywhere and a fire start, a shut-off valve is provided on the main line outside the furnace structure to shut off the oil supply. The floors, stairs, platforms, etc., are entirely of steel, making the whole structure fireproof.

No difficulty is experienced in heating a 60 foot shaft in this furnace to the required temperature with a variation of less than 20 degrees Fahrenheit from top to bottom. These furnaces are all equipped with the latest type Leeds & Northrup recording pyrometers and so arranged that temperature readings may be taken every few feet on the length of the forging from either side or from the top

every few minutes. The indicators are installed in a central pyrometer room where the temperature is continually under observation by expert metallurgists.

This line of work has developed side by side with the forging development so that the Allis-Chalmers Company has now one of the most complete plants in the country.



Interior view of machine shop.

Institute Meeting Indorses Gary's Stand

American Iron and Steel Institute in Favor of Open Shop—International Distinction Given Meeting by Presence of King Albert. Interesting Technical Program Presented.

Unusual interest was centered upon the last meeting of the American Iron and Steel Institute held in the Hotel Commodore, New York, Friday, October 24. Important on account of the industrial situation in the steel industry, Judge Gary's address was looked forward to with more than usual interest. The attendance of King Albert and Prince Leopold added an international distinction to the meeting, which was further emphasized by Monsieur Schneider's description of the struggles of the French steel industry during the war.

The unusual and emphatic support given Judge Gary at this meeting was sufficient evidence that the American Iron and Steel Institute solidly indorses the open shop principle.

Gary Tells Strike History.

Insisting that from 80 to 90 per cent of labor in America is non-union, and that this great group is entitled to a voice in saying whether it shall be dominated by the wishes of the American Federation of Labor, Judge Gary said that "every proposition contended for by the labor leaders at the national industrial conference led to the domination of the shops and the men by union leaders." He attacked organized labor's methods in the steel strike and excoriated Bolshevism.

Immediately after his speech, the 1,500 members present adopted resolutions indorsing the stand taken by him at the conference. The conference, he said, was doomed to failure because of the group system of voting and the closed shop question.

The question between industry and the American Federation of Labor now is mainly whether or not the open shop is to be allowed to continue, declared Mr. Gary, who insisted that the aim of the federation was to force all employers to run a closed shop and to force all workers to join the federation.

In reviewing the steel strike he reiterated that the strike began without any authorization of the workers themselves, and he charged that intimidating letters with threats to burn the homes of those who remained at work, kidnap their children and harm the workers themselves were sent to those who remained on the job or tried to. He charged that W. Z. Foster was the big factor in the strike situation, which, he asserted, is good and steadily improving.

This reference to Bolshevism was cheered.

Mr. Gary was warmly applauded as he arose to speak. He launched immediately into the events that led up to the great steel strike, reviewing the history of the efforts of the American Federation of Labor preparing for the strike.

"The present campaign was started at St. Paul, Minn., June 13, 1918," he said, "by the adoption of a resolution introduced by Delegate W. Z. Foster.

"The movement appears to have proceeded under the general direction of Foster, without much result until June 13, 1919, when another resolution was adopted by the American Federation of Labor at a meeting held in Atlantic City. The resolution authorized President Gompers to call a conference of the heads of all international unions affiliated with the A. F. of L. to the end that they make arrangements to lend their assistance to the organization of the iron and steel industry.

"The strike, which has been directed by the union labor leaders and was begun, so far as I am informed, without any request or authorization from the workmen themselves, has been conducted in the usual way.

"Immediately preceding the day fixed for ordering out the men, intimidating letters, large numbers of them anonymous, were sent to the families of the workmen threatening physical injury to the father or husband, damage to or destruction of the home, and kidnapping of the children unless the employe referred to should obey the order to strike. The larger number of employes continued to work without interruption.

"After protection was afforded by the police, sheriffs, deputies, state constabulary and, in some cases, state or national troops, the numbers resuming work increased appreciably from day to day until in many places operations are about normal. Taken as a whole the situation at present is good and steadily improving."

"Without discussing for the present the merit or demerit of labor unions it may be observed that union labor leaders openly state that they seek to unionize or, as they say, 'organize' the whole industry of this country. Those who do not contract or deal with unions, although they do not combat, insist upon absolute freedom to both employer and employe in regard to employment and the management of the shops.

"The non-union employers and employes both stand for the open shop. The unions argue for the closed shop or, as the leaders now insist, 'the right of collective bargaining through labor union leaders.'"

"Every proposition contended for by the labor unions at the national industrial conference at Washington led to domination of the shops and of the men by the union leaders. Every position taken by the other side centered on the open shop. This is the great question confronting the American people and, in fact, the world public.

"From 80 to 90 per cent or more of labor in this country is non-union. It is for them and the employers generally, and the large class of men and women who are not, strictly speaking, employers or wage earners, to determine whether or not it is best for the whole community to have industry totally organized.

"Judging by experience we believe it is for the best interest of employer and employe and the general public to have a business conducted on the basis of what we term the 'open shops', thus permitting any man to engage in any line of employment or any employer to secure the services of any workman on terms agreed upon between the two, whether the workman is or is not connected with a labor union. The verdict of the people at large will finally decide this question and the decision will be right.

"I think the fundamental question submitted to the conference for recommendation to industries was the open shop. That question apparently could not be decided by majority vote for the reason that the conference was organized into three groups called labor, employers, and public.

"The union labor advocates stand for collective bargaining through the unions. The others favor collective bargaining through representatives selected by the employes themselves from their own number."

The speaker sketched briefly the events that led up to the dissolution of the industrial conference.

"All through the conference whenever the question of collective bargaining was discussed, it was apparent that the union labor leaders would not support any resolution in favor of collective bargaining except on the basis that collective bargaining meant bargaining through labor unions.

"In the conference there was no objection offered by anyone to a form of collective bargaining as between employes and employers, provided both were free from outside representation and direction.

The labor group, so-called, was made up of union leaders, leaving unorganized labor without special representation.

"The employers' group, in which were men first class in every respect, included men connected with large and important lines of industry, and also included several others, some of whom at least should have been with the labor group.

"In selecting the public group there were overlooked thousands of vocations, professions, artisans, and other lines of industry, all of whom are more or less affected by the cost of production, the expense of living, and, therefore, the control and conditions of both labor and capital.

"With the right disposition and intelligence the public group, sole survivor of the conference, can agree upon recommendations to the industrial world which should be of substantial benefit. All of us are in favor of these principles and of any others that may be sug-

gested which we believe will be of real benefit to the wage earners and to the general public.

Considerable has been said in public of late concerning the attempt to spread the doctrine of Bolshevism in this country. All of us have known for some time that this disease is persistent and that there has been some inoculation even in this best of countries. Still we deny that there is danger of serious trouble. There is only one way to treat this disease and that is to stamp it out, to meet it boldly wherever it can be found, to expose it and give it no chance for development. In this free country, with its reasonable laws wisely administered, its golden harvests, healthful climate, peace-loving inhabitants who are generous in contributions for relief and protection: schools, churches and hospitals, there is no room except in the prisons for the anarchist, the Bolshevist, or other individual who seeks to substitute the rule of force for the rule of law and reason.

"We shall emerge from the waves of unrest which naturally follow the demoralization and terrors of war, and as a people will be better and stronger than ever."



VAN H. MANNING.



H. M. HOWE.



W. E. RUDER.

The technical session of the institute offered a number of interesting papers and discussions: W. E. Ruder read a paper entitled "X-Ray Examination of Metals." H. S. Rawdin of the Bureau of Standards discussed this paper. A paper

entitled "Magnetic Analysis of Steel was read by R. L. Sanford of the Bureau of Standards. This paper was discussed by Dr. H. M. Howe. Wilford Sykes presented a paper on "The Electrification of Reversing Mills," which was discussed by D. B. Rushmore. Other papers presented at the technical session were: Dr. Henry M. Howe, "The Open Hearth Furnace and Processes;" G. K. Burgess, chief of the division of metallurgy of the Bureau of Standards, "Temperature Measurement in Steel Furnaces;" and Lawford H. Fry of the Standard Steel Works Company, Burnham, Pa., "The Manufacture of Ingots for Locomotive Tires and Rolled Wheels."

Monsieur Schneider in speaking of the conditions of the steel industry in France during the early days of the war said in part: "I do not know whether in America you fully realize what the war meant to our steel industry, what a terrible blow the war struck it, and to what an almost superhuman test the industry was put. Just remember that at the declaration of war most of our directors, engineers, foremen and workmen were mobilized and that sixty-seven per cent were called to arms."

Heating Furnaces and Annealing Furnaces

Selection of Fuel for a Given Furnace, in Conjunction With Selection of Equipment for Its Economical Combustion. Natural Gas as a Furnace Fuel.

By W. TRINKS.

PART XI.

In the first part of this series the questions which come up in connection with the installation of a furnace plant had been enumerated, and among them was the selection of the proper fuel. In this and the following installments the fuel problem will be discussed in connection with the equipment for the economical combustion of each fuel.

Leaving the indirect use of fuel by electric heating out of the discussion, we find the following fuels burnt in industrial furnaces:

Natural gas, coke oven gas, raw producer gas (hot), clean producer gas (cold), water gas, town (coal) gas, coal for use on grate, powdered coal, fuel oil, tar, kerosene.

There are a few other fuels such as wood, gasoline, etc., but they need not be considered here.

In the selection of a fuel from this group, many different view points enter, for instance, cost of fuel,

reason that almost every manufacturer of equipment for the use of a certain fuel is very ready to see the advantages of using that particular fuel, and that very few of these manufacturers are willing to concede that it may, in certain cases, be more advisable to select a fuel for the use of which they do not make any equipment. And even if the manufacturers do take a broader viewpoint, their sales agents persist and insist that the fuel for which they sell equipment is the only salvation, and that the new furnace installation is bound to be a dismal failure, if any other fuel is used.

With these facts in mind, a classification of furnace fuels can be made. One of the principal lines of separation is furnished by the size of the installation. Certain fuels are available for large furnace plants only, while others are useful for small plants only.

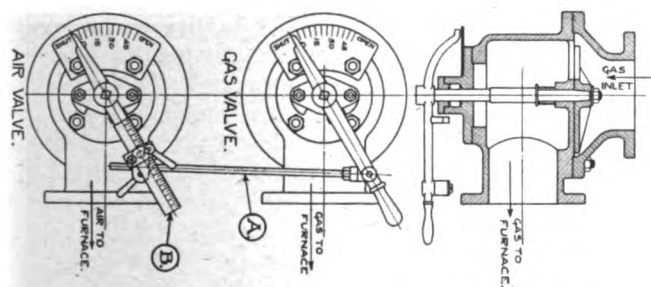


Fig. 75—Sketch of interconnected regulating valves for gas and air. Note the adjustability of length of connecting link A and of length of one of the lever arms B.

and the effect of the fuel on the quality of the material to be heated or annealed. Another consideration is that of continued, uninterrupted supply of fuel. Another factor of greatest importance is the labor cost connected with the use of certain fuels. And finally, there is the question whether equipment is on the market for economically burning a given fuel.

Since so many factors enter into the final decision, the method of selection is almost invariably one of the elimination of the fuels which are least fitted for the case in question. While the elimination is largely affected by local conditions, certain general guide methods for the elimination stand out boldly, and will be discussed here.

But before this discussion is started, the statement should be made that the author expects the instalments on fuel and fuel burning equipment to be less satisfactory and to be attacked more than any other part of this series of articles, for the simple

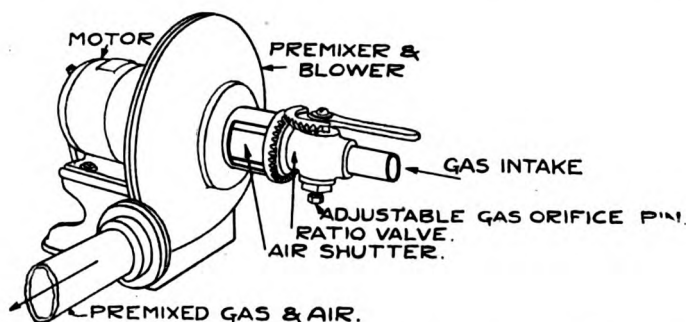


Fig. 76—Sketch of Maxon Premix burner. Note interconnection of regulating valves for gas and air by means of bevel gears, also independent adjustment of gas valves.

The fuels which are applicable in large plants only are, producer gas, both raw and clean, coke oven gas, water gas, and powdered coal. The fuels which are to be considered for small plants only, are kerosene and town gas. The reasons for this distinction are plain. Gas producers, coke ovens, water gas plants, and coal pulverizing plants are expensive, if installed for small quantities, as will be seen from the figures given under the respective fuels. They are practically never used for furnace installations requiring less than 2,000,000 British thermal units per hour, and become more and more economical as the size of the installation grows. On the other hand, the price of town gas is such (from 80 cents to \$1.00 per 1,000 cubic feet of 600 Btu per cubic foot) that its use is justified in very small furnaces only. For the comparison with other fuels it may be remarked that this corresponds to a cost of \$1.50 per 1,000,000 Btu.

A second distinction may be based on the con-

tinuity of operation. The before mentioned fuels such as producer gas, coke oven gas, water gas and powdered coal presuppose a fairly continuous operation, not necessarily per furnace, but per group of furnaces. If the demand for fuel is very variable, and if natural gas cannot be had, oil is to be preferred, because it can be shut off and stay shutoff without any standby loss.

Further than that, no generally applicable rules for the use of a special fuel can be given. It is, therefore, advisable to go over the list of fuels and to bring out their characteristic properties, and to discuss their

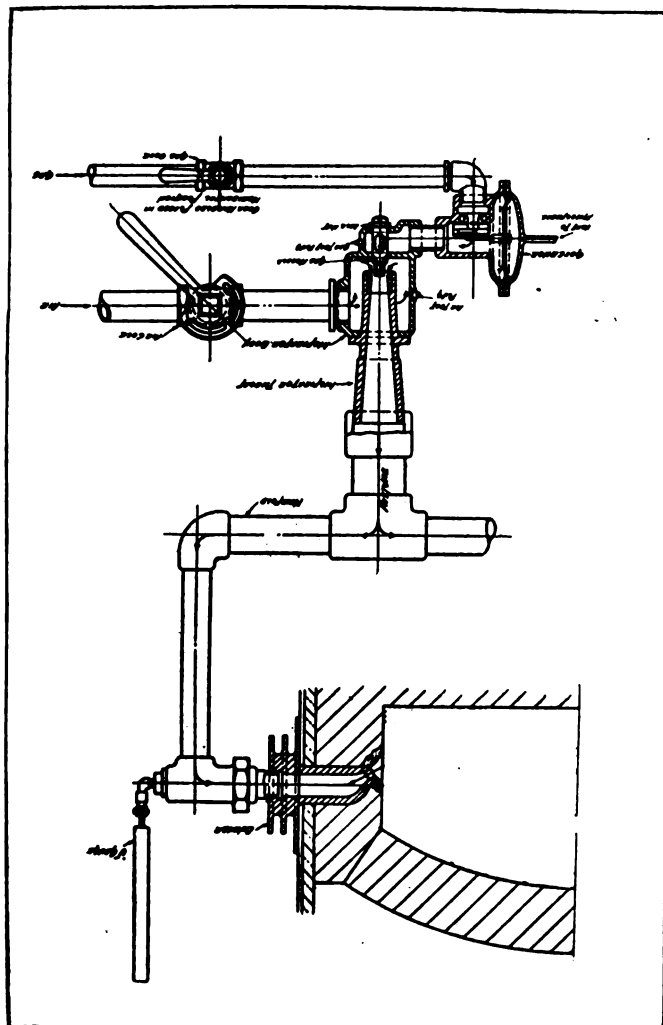


Fig. 77.

limits of applicability, keeping in mind the available equipment for their economical combustion.

Natural Gas.

This fuel is, without any doubt, the most desirable fuel for heating furnaces and for annealing furnaces. It is clean, free from dust or sulphur, it can be burnt with either a luminous flame or with a blue non-luminous flame; it has a high heat value, and allows high temperatures to be obtained without pre-heating of the combustion air. With the exception of very few localities, the heat value of natural gas ranges between 900 and 1,100 Btu per cubic foot (62 deg. F. 30 in.) depending upon the amount of illuminants contained in it. On account of its high heat

value, the gas can be transmitted through small pipes. Its use causes no standby losses.

Unfortunately, natural gas is becoming scarce in many industrial districts, and is frequently turned off during the cold winter months. In other districts it is being diluted with water gas of lower heating value, particularly during the colder season. This latter practice results in delivering a gas of varying heat value and makes continuously perfect combustion with the correct quantity of air almost impossible.

If natural gas of an unvarying heat value is delivered, its combustion can continuously be obtained

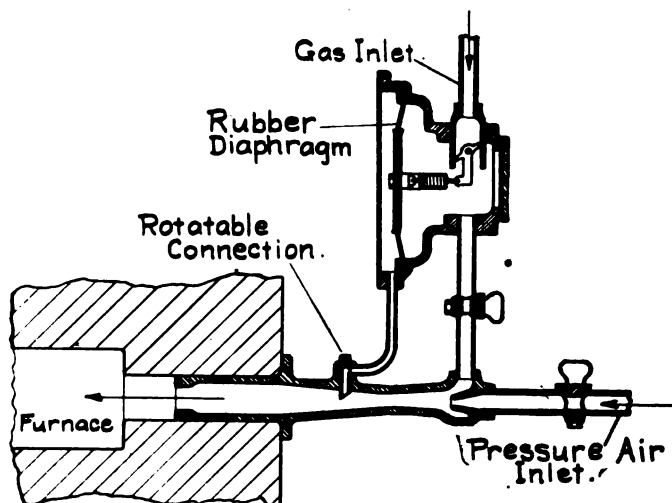


Fig. 78.

with practically the theoretical quantity of air, either by interconnection of the air and gas ports, or else by properly designed injectors, in which the gas is aspirated by a current of air (or vice versa). In any one of these arrangements it is absolutely necessary to deliver the gas at a constant pressure, which latter must be kept close to that of the atmosphere. Many

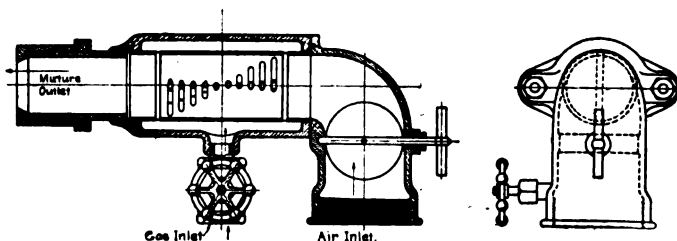


Fig. 79.

disappointments have resulted from failure to observe this rule.

Devices of the first sort are used by A. L. Stevens, of Chicago, and by the Maxon Premix Burner Company. The Stevens device is diagrammatically shown in Fig. 75, while the Premix burner is shown in Fig. 76.

Both devices require a blower. If gas and air are not mixed until they reach the furnace, the characteristic of the blower must be adapted to the design of the furnace and to the pressure drop through the gas pipe between pressure regulator and furnace, or vice versa. Failure to do so results in a pressure difference between air and gas at some rate of driving, which condition means either excess of air or excess

of gas, both of which are undesirable. In that case, a careful heater will invariably disconnect the gas valve from the air valve and regulate the two independently, which again is undesirable, because a careless heater on the night shift will use the valves incorrectly in the disconnected state and produce very bad results. If on the other hand, the proportions of the valves and of the linkage are correct, if gas and



Fig. 79 a.

air pressures are maintained at the proper values, and if gas and air are thoroughly mixed in the furnace, combustion will be perfect and a neutral flame will

The same holds true of the ejector premixers of the type which, in the United States, is made by the Surface Combustion Company and by Tate-Jones & Co., and which is made by Keith & Blackman in England. These devices are shown in Figs. 77 and 68. In the latest surface combustion premixers, see Fig. 77, the gas is delivered under high pressure, and air is induced. This arrangement has the great advantage of doing away with a pressure regulator, because the induced air is always at atmospheric pressure. It has, however, several disadvantages. First, variation of barometric pressure causes errors in gas to air ratio up to 5 per cent. Second, for natural gas as the fuel, the gas must be compressed to 15 pounds per square inch in order to induce enough air for combustion. Third, the air cannot be preheated. The high compression is necessary, because of the great loss which occurs, when a small, high velocity mass moves a much larger mass by impact. Preheating of the air is undesirable, because the resistance of the recuperator or regenerator to flow of air interferes with delivery of the air at constant pressure, if the rate of flow

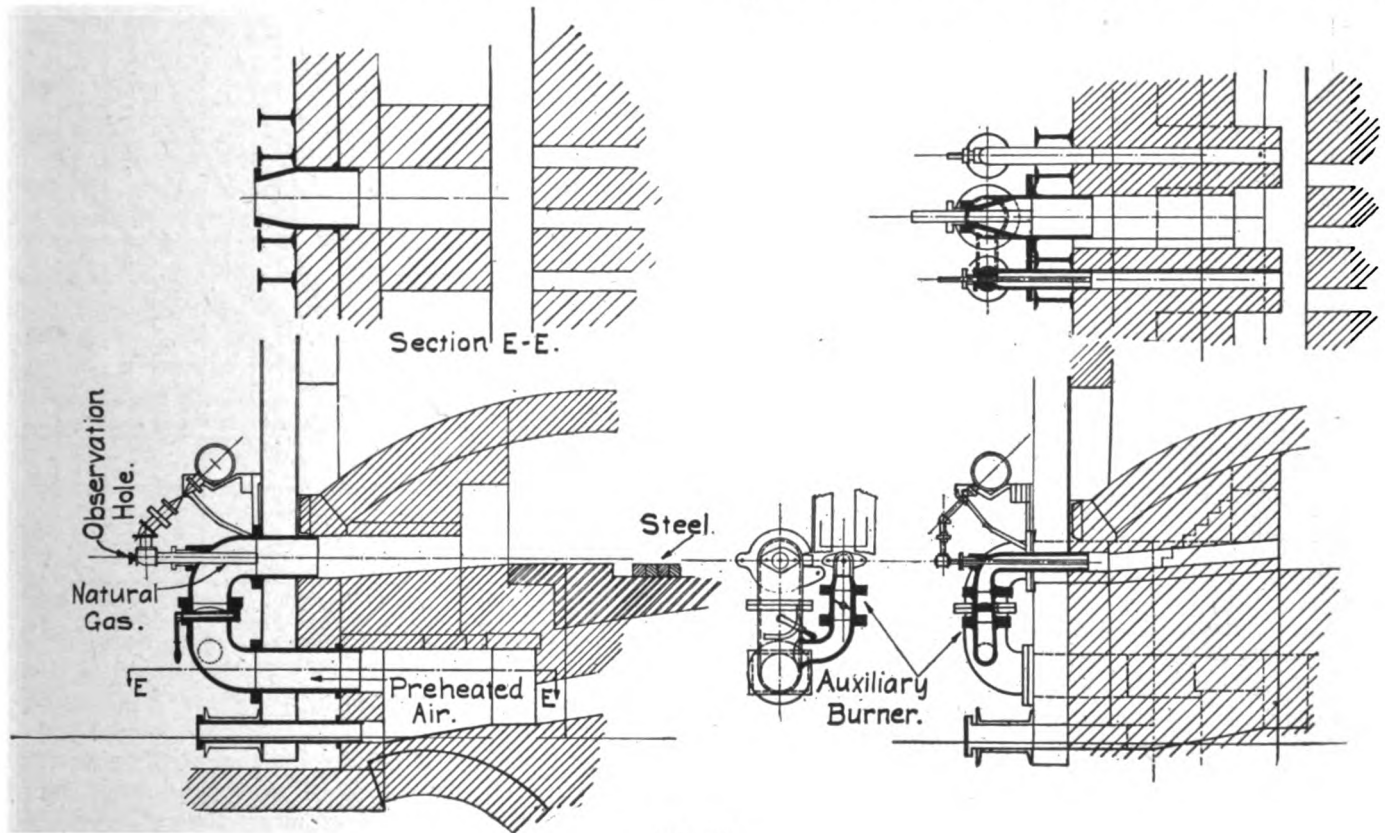


Fig. 80.

be produced, unless the heating value of the gas varies.

The Premix burner, Fig. 76, is, likewise, quite sensitive to variations in gas pressure, and requires a very sensitive pressure regulator. If the gas is not delivered at atmospheric pressure, it is impossible to maintain the correct gas to air ratio over a wide range. The Premix burner does not lend itself to a considerable preheating of the air, on account of the danger of ignition of the explosive mixture between mixing fan and furnace, and on account of the variation of the volume of the preheated air.

varies.

These circumstances caused Keith, who used the high pressure gas ejector with air induction before the year 1913 to go back to the air blast with gas induction, see Fig. 78. In numerous tests which I have made with ejectors, inducing either fuel or air, I found that it is extremely difficult, if not impossible, to maintain a constant gas to air ratio over a wide range of flow, and with varying back pressures, arising either from manipulation of flue dampers or from pressure head caused by friction of gas-and-air-mix-

ture. Keith attempts to overcome these difficulties by letting both static and dynamic head in the expanding tube of the ejector act upon the gas regulator. By a part rotation of the inclined-cut tube in the nozzle the dynamic head can be adjusted, and the tendency to give too much gas at high rates of flow can be compensated for.

In connection with the subject of premixing burners mention should be made of the most of premixing burners with independent adjustments for the flow of gas and of air. An example from the multitude of

short a distance from the burner and produces "hot spots." This fact has at times been praised as an advantage of premixing and has been used as an argument against preheating of combustion air on the basis that the concentration of the flame allows the reaching of sufficiently high flame temperatures without preheating. But no such argument is valid with natural gas as a fuel, because that fuel permits high flame temperatures even with delayed combustion, which latter causes a more uniform temperature to exist. Fig. 80 shows a burner arrangement in which

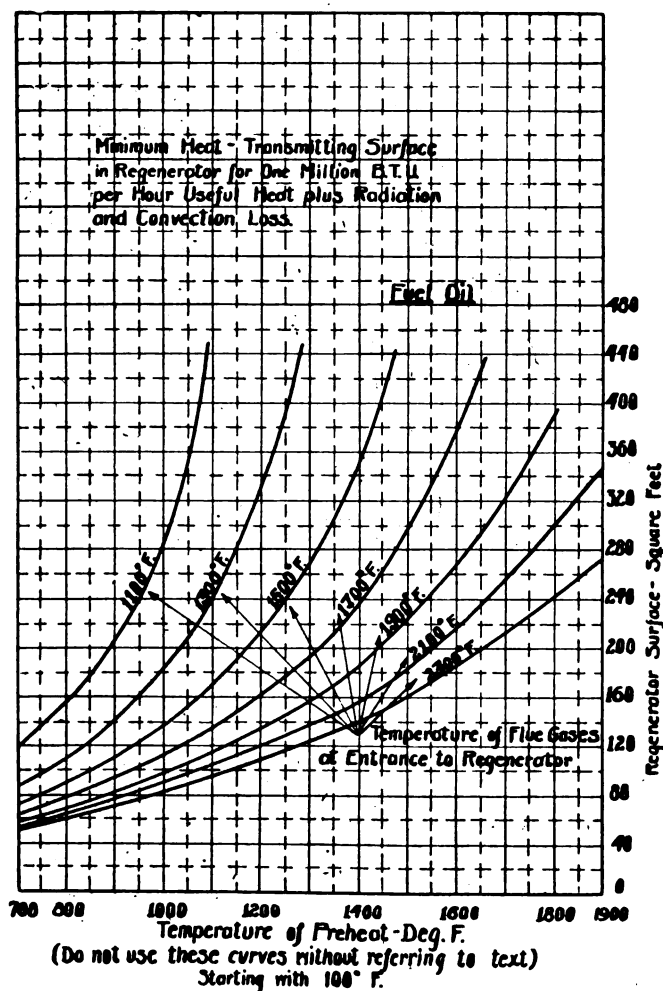


Fig. 60.

these burners is shown in Fig. 79 and 79a (Tate-Jones type). The successful use of any one of these burners requires the services of an ever watchful and experienced fireman who can tell from the appearance and from the color of the flame whether or not he is operating with the correct air to gas ratio. Reputable firms know the limitations of this type of burner, but month after month inventors bob up with new types of premixing gas burners that "get more heat out of the gas than there is in it." As a rule it is quite difficult to convince them of the fallacy of their ideas.

Many furnace engineers object to premixing of gas and air because it concentrates the flame within too

I have been informed that negotiations are pending to introduce Keith's ejectors in the United States through the Tate-Jones & Co.

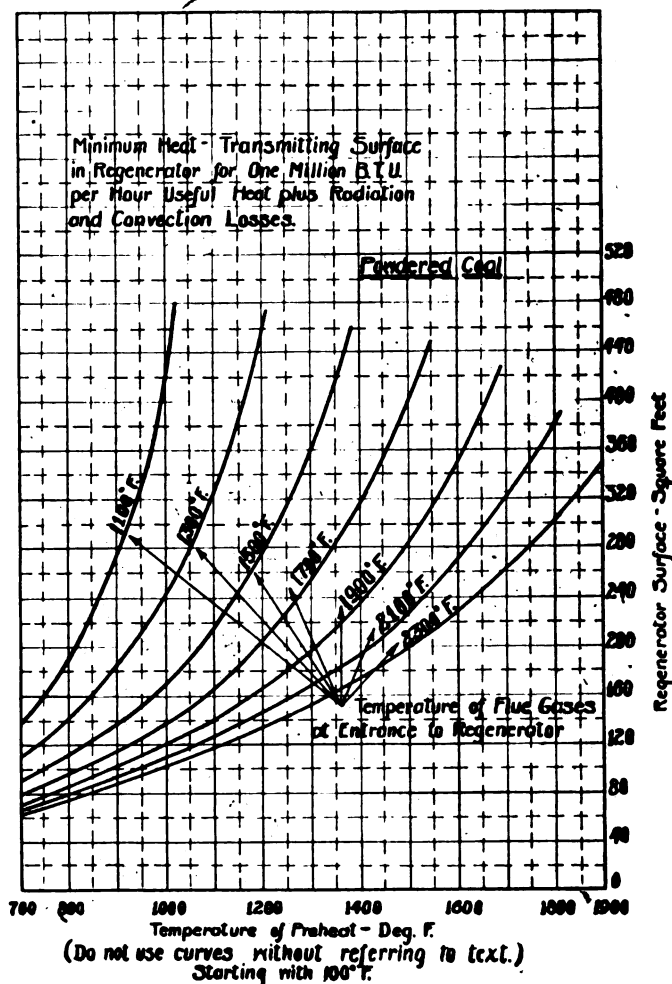


Fig. 61.

the length of the flame depends upon the size of the burner. Many small burners mean short flames, while a few large burners mean long flames. This fact was pointed out early in this series, and is repeated here because of its importance. The long flame is surrounded by free oxygen which means that the current of burning gases must be kept away from the metal which is being heated. With natural gas there should be very little difficulty in accomplishing this feat, particularly if the air is preheated, because the density of natural gas is about two-thirds that of air. If the gas is introduced below the air, the difference in densities will cause only a very slow dropping of the air, and if the latter be preheated, it will float on top without ever touching the steel.

It is interesting to note that the burner shown in

Fig. 80 is to a certain extent a premix burner, because the gas is injected into the air stream some distance back of the mouth of the burner. The distance from the mouth of the inner (gas) pipe to the mouth of the burner determines the thoroughness of the pre-mixing. The flame is formed at the mouth unless the velocity of flow is so small that the flame blows back. For that reason, separate smaller burners are provided for use at such times when the rate of heating is below the blowing back rate of the large burners, for instance, over Sundays, or when there is a shutdown in the mill.

Natural gas itself is practically never preheated. First, the gain would be very small, because its weight is less than 1/15 of that of the combined fuel and air

mixture. Second, because it breaks up at high temperatures and deposits lampblack.

The cost of natural gas varies widely in different sections of the United States. In some sections of West Virginia it is sold for 5 cents per 1,000 cubic foot, while its price in the Pittsburgh district is 35 cents per 1,000 cubic feet. The latter figure roughly corresponds to 35 cents per 1,000,000 Btu. However, the price is not stable and has a distinct upward trend.

Correction.

In Part VIII of this series the curves in Figs. 60 and 61 were marked with the wrong temperatures. In consequence, we reprint these curve sheets here with the correct temperatures.

Suggestions for Tar Extractor Improvement

Wheel Type Extractor of Corrugated Sheets for Efficient Cleaning, Automatic Control, Instant Adjustment of Gas Pressure and Long Operating Period—Shutting Down of Extractor Avoided.

By GEORGE B. CRAMP.

With the exception of power driven machinery practically all gas, air or vapor apparatus may be divided into four distinct types; namely, the direct contact type, the indirect contact type, the impact or filter type and lastly the electric type. By direct contact is meant the direct contact of the gas with the washing, cooling, absorbing or distilling medium used in treating the gas. The gas washer as described in the September issue of THE BLAST FURNACE AND STEEL PLANT is of this type.

Indirect contact has reference to the apparatus generally used for cooling or heating gas and wherein the cooling or heating medium used does not come into direct contact with the gas to be cooled or heated. The primary cooler described in the October issue is of this type.

Impact or filter refers to the apparatus wherein no medium is used and in which the gas is either caused to come, at comparatively high velocity, into contact with baffle surfaces by which impact it impinges the dust, tar or other matter against the surfaces provided; or, as in the filter types, is caused to pass through a filtering substance such as mineral or steel wool, spun glass, etc. The tar extractor herein described is of the impact type.

Electric apparatus for dust and tar precipitation is of comparatively recent development, and of growing importance to which the common principle and construction applied to other apparatus is also applicable; but the discussion of which will not be taken up until all byproduct apparatus in the order of byproduct recovery has been covered.

Referring to the last article in the October issue, on the primary cooler, it will be noted that the gas is drawn through the primary cooler from the coke ovens by the suction fan, or exhaustor. In passing through the cooler the gas is cooled and drops by condensa-

tion and contact with the tubular surfaces of the cooler about 80 per cent of the tar originally suspended within the gas in vapor form. From the ovens through the cooler to the exhaustor the gas is under suction, and from thence it is under pressure sufficient to force it through the various apparatus. The first of this apparatus is the tar extractor, which as above stated is of the impact type of apparatus; the function of which is to remove from the gas the final tar mist or fog which has not been brought down within the primary cooler and which amounts to practically all the remaining tar or 20 per cent of the total original content of the gas. The tar mist, or fog is said to exist in the gas in the form of bubbles which are films of tar enveloping minute bodies of gas, much as a film of water, or bubble envelopes a body of air.

The most commonly used type of tar extractor employed in byproduct recovery practice is the so-called P and A, which letters represent the initials of Pelouze and Audouin, two Frenchmen who over 30 years ago invented it. The principle of their device is correct and the design has undergone practically no change since its inception. The construction of the P and A is embodied in the tar extractor represented by Fig. 1 and its accompanying sections AA and BB. Instead of the counterbalance weights, however, the handwheel is shown here, it being the more recent and generally adopted method of operating the extractor bells.

The extractor shell is usually of cylindrical steel construction with a horizontal diaphragm imposed just above the gas inlet. This diaphragm is pierced by either one large or several smaller tubes equal in cross sectional area to the gas inlet. The tube or tubes direct the gas upward and out into the upper inside of the rectangular boxes or bells hung over each tube, the bottom end of each bell being open for this reason, the top being gas tight.

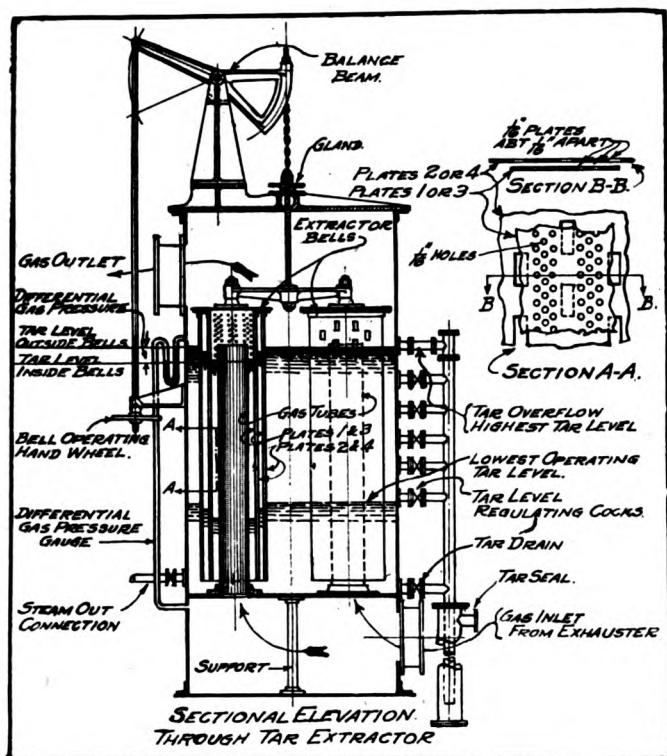


Fig. 1.

These rectangular bells are usually formed of 16 thin plates arranged two to a pair and two pairs to a side, there being ordinarily four sides to a bell, and for reference the plates are numbered respectively 1 to 4 from the inside of the bell outward, or in the direction of the flow of gas through them. The edges of the plates or corners of the bells are made gas tight and the gas must pass through the four side plates in order to travel from the inside to the outside of the bells as the lower ends of the bells are sealed in a bath of tar which prevents the passage of gas in that direction.

Plates 1 and 3 and plates 2 and 4 are alike as to perforations and arrangement as shown in sections AA and BB of Fig. 1.

It will be noted that the gas first passes through plate 1 which is perforated with holes $\frac{1}{16}$ inch diameter. These holes register opposite a blank surface of plate 2 against which the gas is caused to project at high velocity. The resultant impact flattens out the jet of gas and the tar bubbles are impinged against the inner surface of plate 2 and are thus caused to burst releasing the imprisoned body of gas. The tar films themselves adhere to the plate surfaces and gradually collect forming drops of tar which unite and flow down the plate surfaces into the tar bath below. The gas travels rapidly at right angles to the direction traveled through the round holes in plate 1 and thence between plates 1 and 2 to the rectangular openings in plate 2, through which openings it then passes.

The action of the gas in traveling through plates 3 and 4 is identical to its action in passing through plates 1 and 2. After the tar has once formed into drops it is not again picked up and carried along by the gas which after passing through the extractor bells passes out of the extractor outlet and into the gas main.

From the foregoing it will be seen that the gas in passing through the tar extractor is subdivided into extremely small bodies or jets which are brought into intimate contact with the proper impinging surface, thus accomplishing the extraction of the tar. This is substantially the principle applied to the gas apparatus described in previous issues of this periodical and by reason of the application of this principle to the P and A tar extractor it is one of the most efficient pieces of gas apparatus developed when working under uniform conditions.

However, there are some difficulties in the construction and operations of the tar extractor as above described. First it requires very careful layout and

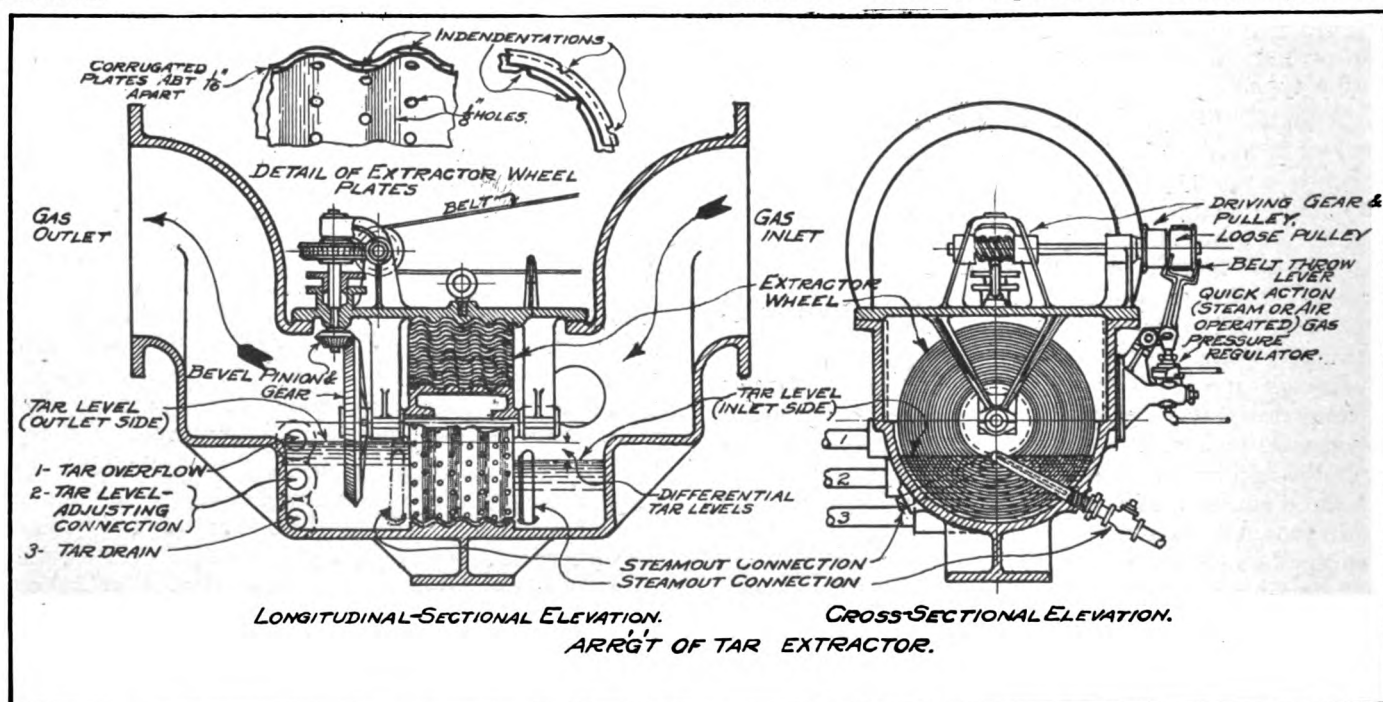


Fig. 2.

spacing of the holes and assembly of both sets of plates forming the bells. Comparatively thin plates must be used, which under an increase of pressure above the normal, tend to bulge apart and permit the gas to rush between them uncleaned. Secondly there are so many of the small holes required to handle a given quantity of gas that the size and number of bells required to handle quantities of gas such as are handled by numbers of these apparatus in the usual byproduct recovery plant are of such size and weight as to make the balancing, especially in the larger apparatus, a difficult problem. Thirdly the length of bells required to give the extractor as long an operating period as possible, are of such dimensions as to require a building higher than would be required for the accommodation of the other apparatus, it being necessary at times to remove the bells from the shell by use of a crane which necessitates additional head room. Attempts to balance the bells by counterweights to obtain automatic action have been so unsatisfactory that nearly all extractors are now operated by the hand wheel, as shown in Fig. 1. These require operation by an attendant when it becomes necessary to raise or lower the bells.

The largest tar extractor installations have stationary bells and the tar level is raised and lowered automatically by a pressure operated regulating valve which controls the tar level. This method of operating is as a consequence slower in relieving increased gas pressure within the bells than a well attended hand operated extractor would be. Should the pressure fall slightly lower than normal it is slower in building up the tar level to the height required to restore the normal working pressure.

From the foregoing it will be understood that raising the bells out of the tar bath in a movable bell ex-

tractor, or dropping the tar level in a stationary bell extractor results in a reduction of pressure of gas within the extractor bells by reason of additional small holes in the bells being opened for the passage of gas through them. Likewise the dropping of the moveable bells and the raising of the tar level in the stationary bell extractor reduces the number of openings for gas passage and raises the gas pressure with the bells.

Raising of gas pressure within the extractor bells occurs after a continued operation during which time the gas has dropped the tar fog in passing through the extractor, along with some naphthalene which with some pitch solidifies on or between the bell plates plugging the gas passages. Under normal working conditions these deposits form very slowly or are kept dissolved and flashed off the plate surfaces by the films of tar continually flowing over their surfaces. Sudden raising of pressure of gas within the bells occurs when gas overburdened with tar passes through the extractor depositing so much tar between the plates as to momentarily clog the gas passages thus piling up gas pressure.

This pressure may be relieved by raising the bells out of the tar bath by means of the hand wheel thus exposing new openings for gas passage. It may happen after an interval that the bells may be restored to their original position, should the gas pressure by the new adjustment fall below normal but usually the adjustment remains stationary until another increase in gas pressure occurs when the adjustment must be repeated. Finally the bells are raised to the highest position and further adjustment is accomplished by lowering the tar level within the extractor by simply

(Continued on page 576)

Electrically Driven Reversing Rolling Mills

Brief Review of Factors Leading Up to the Development and Use of Reversing Rolling Mills—Reconstruction of Steel Mills in Future Will Mark Further Electrification.

By WILFRED SYKES.

We are becoming so accustomed to the use of electric machinery in our daily life that sometimes the significance of the change from past practice is not appreciated. I believe this is true to some extent in regard to the electrically driven reversing rolling mill which has been quite extensively used in the last few years, and it is the object of this paper to briefly review the factors that led up to its development and use and to summarize the present state of the art.

Perhaps a brief historical review will be of interest when considering the development of this class of equipment. The idea of using electric motor for driving rolling mills was first exploited in Europe where a number of small equipments were installed about 20

years ago. These were all used for driving mills running in one direction, and the machines were of the types already developed for other purposes. The ease with which the extension of the plant could be cared for, and the freedom from restrictions as to distance from the boilers, was quickly appreciated, even before the economical advantages of electrification were realized. The concentration of the generating equipment into large units of the highest economy with the corresponding reduction in total capacity required and very much higher average load, together with the fact that the distribution loss is trifling and varies with the load, was not given consideration until a later date.

About 15 years ago, the number of machines installed had grown considerably, and about this time,

Paper read before New York meeting of American Iron & Steel Institute.

a start was made in this country when two 1,500 hp motors were built for driving the No. 3 rail mill at Edgar Thomson plant. The problems involved in the design of such plants as Gary required a radical change from past practice, and the advantages of electric drive having been more clearly developed in the meantime, it was natural that electricity should be the medium for transmitting the energy from the power plant to the wide spreading mills which could then be distributed solely with regard to the proper handling of the material.

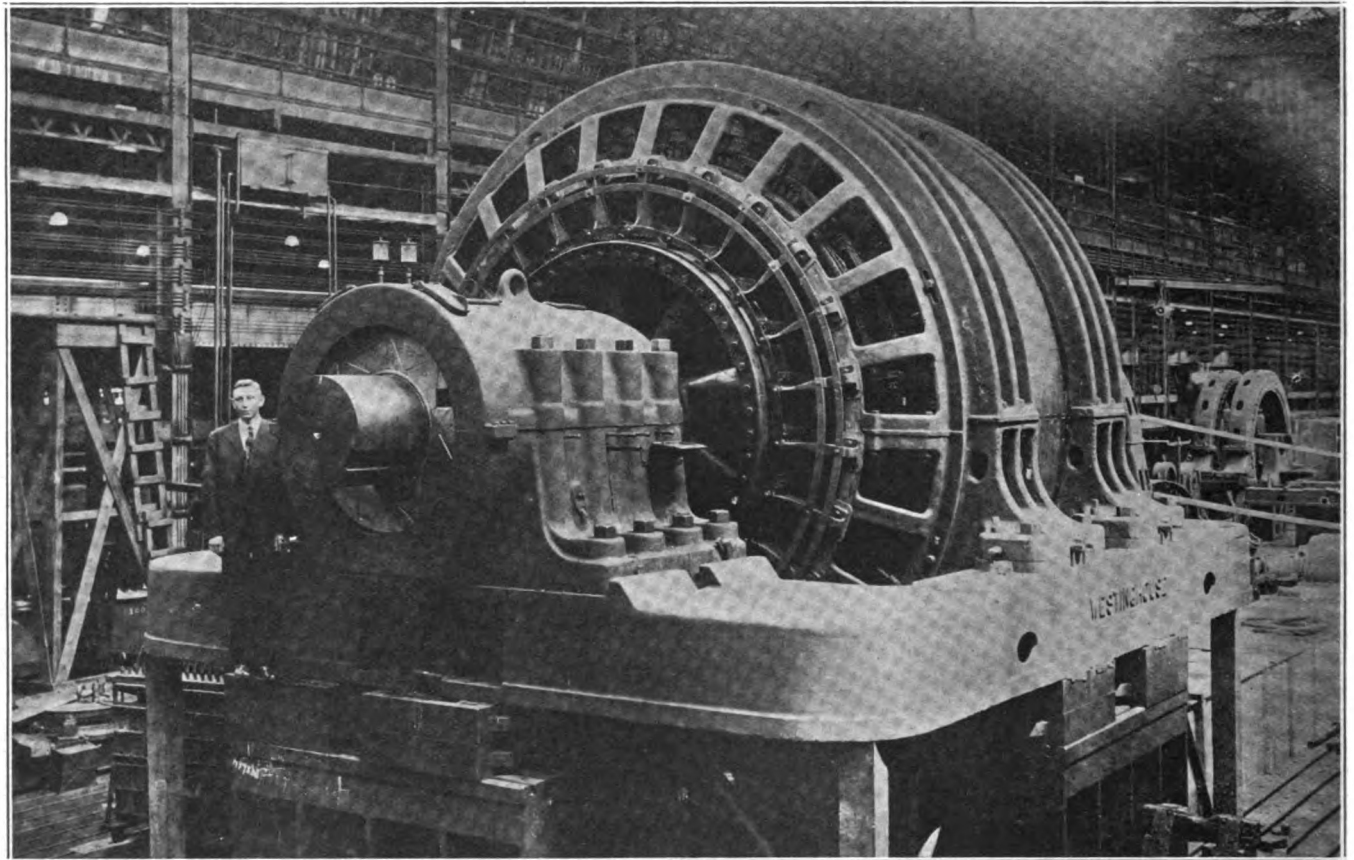
Since then the development has been rapid and the great majority of new mills in the last 10 years have had electric drive.

With regard to the electrification of a complete

tial installation in Europe having been made a little ahead of that in America, but the work was entirely independent. We will confine ourselves to the plants on this side of the water in this discussion, but it might be well to mention that for a time the development was more rapid in Europe owing to a quicker appreciation of the advantages and economic conditions that favored the construction in Europe when practically nothing was being built here.

There are two questions that must occur to anyone having to decide the type of power to be used in his mill. They are:

1. Will the type of drive meet all the requirements of production?
2. Will it be the most economical that will satis-



Reversing motor, 15,000 hp maximum capacity for driving blooming mill, showing mill end of motor with thrust bearing.

steel plant, there was for a number of years a big question as to the possibility of using motors for reversing mills. Many steel men felt that the motor was all right for continuously running mills and could appreciate the economic advantages, but when it became a question of a reversing drive on, say a booming mill, they felt that it was questionable, and that perhaps the safe course would be to use the old fashioned steam engine. A few years has changed all this, so that today the electrically driven reversing mill is comparatively common, and there is no longer any question of its ability to do the work and do it economically.

The electrically driven reversing mill had a simultaneous development in Europe and America, the ini-

fy the first condition?

Production carries with it all questions of reliability, ease of operation and the fitting of the characteristics of the drive to the requirements of the mill. Economy covers all items of cost such as fixed charges, power cost, labor, maintenance, stores, etc., so that an answer to these two questions satisfies the usual mill man.

There is one other factor not quite so tangible, but of the greatest importance in the development of a plant, and that is the question of layout. We do not have to seek very far for examples of the restrictions that power distribution has had on mill layouts with the accompanying congestion, and consequent greater cost of handling materials. With the use of electricity,

we suffer no practical restrictions so that our plants may be laid out with regard only to the facility for transportation of materials and although this does not show itself directly in costs, when the plant as a whole is taken and compared with others, very gratifying results are obtained.

The reversing motor has been used for all types of reversing mills and to date has not found its limitations. Blooming mills, billet mills, plate mills and structural mills have all been electrified with success. The first installation put in operation 12 years ago at the South Works of the Illinois Steel Company drove a two-high universal plate mill, and I feel that it is only proper to pay a tribute to the foresight and courage of those responsible for the decision to make this initial experiment. The coöperation of the mill engineers with the manufacturers led to a successful plant which has given excellent service to date, and will undoubtedly do so for many years to come. For many years, this plant stood alone, and there were still doubts in the minds of many regarding the ability of a reversing motor to drive a blooming mill which might well be described as the heart of a steel mill. It was recognized that the work was hard and reliability was of the utmost importance, even more important than economy. It remained for our neighbors in Canada to carry out the first successful blooming mill drive, and all honor is due to Robert Hobson of the Steel Company of Canada for taking the responsibility of tying up his new plant to the comparatively untried electric drive, especially in view of a rather unfortunate experience of another plant that made a similar experiment. I believe that it is safe to claim that this installation has been a success and it was the forerunner of the numerous plants that have been built since, many of the earlier installation having been made on the basis of data so generously supplied by this plant.

The principal part of an electrical reversing drive is, of course, the motor connected to the mill. These motors are direct current machines and differ little in general characteristics from those with which we have been long familiar. There are, however, many special features that play a most important part and that spell the difference between success and failure. Of first consideration must be the mechanical construction and this must be beyond question. We must make a closer study of the details of construction than is usual to insure there can be no relative movement of parts under the severe shocks that the motor has to stand, and prudence requires that all parts be so strong that in case something must break about the mill, it will not be the motor. Together with this, we must keep our design balanced so that the weights of our moving parts are not excessive, as an appreciable amount of energy is required to accelerate and retard the motor itself. Good engineering requires that like the famous "one horse shay" each part shall be as strong as the other, and all equal to the requirements of the mill. This, of course, presupposes a knowledge of mill requirements by the electrical designer, and the success of this type of installation has

been mainly due to such studies as we have made over a period of many years.

The motor is not supplied with energy direct from the power plant, but through a so-called "flywheel motor generator set." The function of this set is to provide means for controlling the speed and direction of rotation of the motor, and of equalizing the load on the power plant. It would be, of course, very difficult to build any type of controlling equipment that would handle the large current involved in motors of this type, as will be readily appreciated when we think of the flashing and noise made by the controllers for the motors driving the tables, screw down, etc., which seldom exceed 100 hp, whereas our main motor may carry loads 100 times as great. The speed of the motor is proportional to the voltage impressed on it, and its direction of rotation depends on the way the current flows through it. By having a special generator to supply the motor, we can, through the excitation of this generator, vary the voltage and the direction of the main current, and we need handle only about $\frac{1}{2}$ of 1 per cent of the current in the motor. This is, of course, easily done and the control of our 10,000 to 20,000 hp motors is actually better than the control of the table motors.

The second function of our flywheel set is to prevent the terrific peak loads from the mill from being thrown on the power plant. If this were not done, it would be necessary to have large generating capacity running at very low average load to carry the mill. Fortunately, we can equalize the load to a great extent by a properly controlled flywheel which will give up energy during periods of great demand and absorb it during the intervals. For this reason, suitable flywheels are connected to the generators supplying power to the reversing motor and through the aid of suitable controlling apparatus, they are utilized so that the load on the power plant is only about one-fourth of the peaks on the main motor.

For driving the generator and flywheel, some kind of motor is required, and the type is dependent on the power system. This motor is only large enough to carry the average load, and is not concerned with the peaks of the mill motor. The remainder of the equipment is for the purpose of controlling these functions and providing means for measuring and recording the power used. The starting and the control of the speed of the motor driving the set is done by the slip regulator, which automatically slows down the flywheels during peak load, thus causing it to give up energy, and accelerates it during intervals, thereby absorbing energy.

This may seem a rather roundabout system, but its functions admirably, and it does more than a steam engine, inasmuch as it equalizes the load which is of the greatest importance from an economic standpoint.

Brief reference has been made to the mechanical construction of the equipment. The electrical design is of equal importance and it has been through studying mill conditions and the operation of machines built in the past that we are today able to state with confidence that we cannot only equal engine performance, but improve upon it, and do it at a fraction of

the cost of power. There are innumerable details that have been worked out and improvements made which were all required to make a successful drive, and today we can look back on our initial technical difficulties with a feeling that a long road has been successfully traveled and something accomplished of benefit to the industry.

Today we have 28 mills running successfully and a number have been built for shipment to France, Japan and India. They are connected to the best products of our mill builders and may be truly said to represent our best practice.

I will not attempt to give any figures at the present time showing performance of electrically driven mills, as without the fullest details such figures are misleading. In regard to production, it is sufficient to say that investigations we have made of records show that electric drive in all cases is able to hold its own with the best of past practice, and there is ample evidence to show that with the elimination of restrictions in the mill, better performance can be obtained. As to the first cost, the reversing motor and equipment is a little more expensive than a high class engine, all factors considered, but the fuel required does not exceed one-third of that for the average engine, and is less than one-half of that for the best engine we can build. Such items as labor, maintenance, etc., are very small, so that altogether it shows great economy compared with steam drive.

We are accustomed to associate a considerable boiler plant with a reversing engine and it is rather interesting to find that with electric drive the power taken by the reversing motor, compared to the mill auxiliaries, is not greater than it is. A five months average of one plant shows that the main blooming mill equipment took only $2\frac{1}{4}$ times the power required for the auxiliaries of the same mill. This, of course, is simply a confirmation of the figures given before, but when we keep in mind the picture of the boiler plant required for a reversing engine and the relatively small equipment for the auxiliaries, we can appreciate that the electric drive must be economical, when the power used is not much more than twice that for the motors driving the tables, manipulators, screw downs, etc.

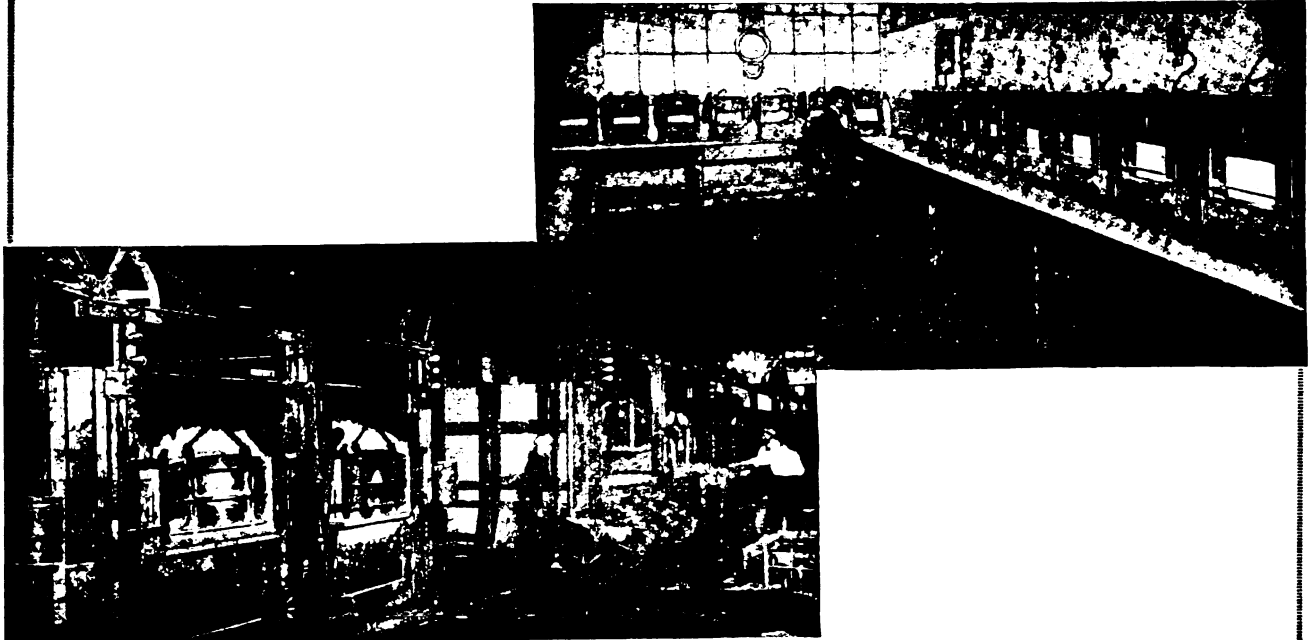
This brings us to one of the most important factors in considering electric drive, and that is, we must consider the power problem of the plant as a whole. It is not reasonable to take a part of a mill and make a comparison of cost of electric versus steam drive, especially where the steam plant may be an isolated unit, as we unduly load the electric motor with a part of the generating plant out of proportion to the real facts. It is where we consider the plant as a whole that the electric system demonstrates its value.

No one questions that the most economical method of making any article is to specialize the plant, installing the best equipment and manufacturing in large quantities. With reasonable distribution costs, such an establishment will eventually supplant the isolated small manufacturer. The whole history of our industrial development bears this out. And so it is with power generation. For economy, we must concen-

trate our power equipment so as to utilize the best that science provides us with. By using large units, the greatest economy is obtained, and the relative labor and other costs are reduced to a minimum. If we then connect to such a power generating station all our power consuming devices, we will find that the aggregate required is less than the sum of the loads on the individual consumers. It is the same as having a diversified market for our products, a dullness of one locality is compensated for by a demand from another, and in this way our average output is maintained approximately constant, which is obviously the most economical condition. If we had to support individual factories to supply all local demands, we would in the aggregate have a capacity out of proportion to our total output. Efficient distribution is the solution in the case of our manufactures, and with power electricity provides the economical means for transporting our power to the consuming devices. The ideal we must work to is to generate our power wholesale and distribute it efficiently. Electricity provides us with a means of using the most economical prime movers, and the consuming devices can be driven with machines that will transform our wholesale generated power to mechanical work with a loss of only a few per cent. It is with such a picture in mind that we must consider electrification of our mills and we then see that electricity is the ultimate means of transportation of our power if we are to utilize our resources to the best advantage. We not only convert more of the heat units in our fuel into useful energy, but we can arrange to take advantage of the overlapping of the fluctuations of the demand of our consuming devices to average them and so keep the rate of generation approximately constant.

With the experience now available, it is beyond question that our power distribution in the future will be by means of electricity, and we should lay out our generating stations with units of such size and characteristics in relation to the ultimate requirements as to get the best economy, and with such a margin of capacity that the electrification of our plants can take place as opportunity offers, without having to consider each time we desire to add a motor whether the generating plant will not have to be extended. We can then modernize our mills as changes are required and ultimately convert our wasteful methods of power generation of the past to the best that we have at present knowledge of. Great force is given to this viewpoint with the rapid rise of fuel and labor costs, two of the principal factors in our power costs. It is wise in this respect to consider the possibilities of ultimately tying different generating stations together for the material benefit of those concerned. In this way, power may be interchanged at times to advantage and the stand by value of such inter-connection reduces the amount of spare plant required with the consequent savings. With electrically driven reversing mills, we can generate our power in the most economical manner possible and transmit it to the mill coupling, allowing for all conversions with a loss of about 25 per cent. The very greater economy of the prime movers used makes this loss relatively negligible, and the net result is as previously stated.

PYROMETRY IN IRON AND STEEL MANUFACTURE



Through the Pyrometer Symposium held at the recent meeting of the American Institute of Mining and Metallurgical Engineers, a great amount of highly valuable information has been made available regarding temperature measurements. In the following pages will be found some of the papers read at that meeting and one which was read before the last meeting of the American Iron and Steel Institute. The papers which appear in this section are:

"Steel Furnace Temperature Measurements"
By George K. Burgess

*"Electric, Open Hearth and Bessemer Steel
Temperature Measurements"*
By F. E. Bash

"Pyrometry in the Blast Furnace Plant"
By P. H. Royster and T. L. Joseph

*"Forging Temperatures and Rate of Heating
and Cooling of Large Ingots"*
By F. E. Bash

Steel Furnace Temperature Measurements

Role Played by the Research Laboratory in the Problem of Measuring Liquid Steel Temperatures—Work of Bureau of Standards and National Research Council.

By GEORGE K. BURGESS,
Bureau of Standards.

FOR several years past, the Bureau of Standards has been actively interested in some of the fundamental problems related to the steel industry, especially subjects of a scientific or technical nature. Among those with which I personally have been engaged, is the question of temperature measurement as applied to the various stages of steel manufacture. The particular phase of this subject, that of the measurement, control, and interpretation of the temperatures of the masses of steel during its manufacture, and while the metal is still liquid, is, perhaps, the most difficult temperature domain to conquer, as it is likewise the most important from the economic point of view.

At the remarkable symposium on pyrometry held in Chicago last month under the auspices of the American Institute of Mining and Metallurgical Engineers there were papers relating to steel manufacture. Such an interchange of viewpoints and experience makes for progress. It was made evident by this symposium, however, that although there have been developed satisfactory instruments for measuring temperature in open hearth and electric furnaces and of liquid steel streams; and there has been made sufficiently exact determinations of the underlying physical facts and phenomena on which such temperature measurements are based; and also there has been accumulated a considerable mass of experimental data relating to furnace operations by various observers; and above all, there has been unquestionably established a most splendid spirit of confidence and co-operation among the steel maker, the scientific man and the instrument manufacturer.

As illustration of the role played by the research laboratory in the problem of temperatures of liquid steel, let us take the determination of the corrections to be applied to the optical pyrometer readings to give true readings. The need of such correction arises from the well known fact that the intensity of total and also of monochromatic radiation of any substance, not enclosed within a furnace uniformly heated, depends not alone upon its temperature but also upon the nature and character of the radiating surface. It then becomes necessary in the case of liquid iron, steel, oxides, and slags, for example, to find their emissivity or specific radiation for the colored light used with the pyrometer. This can best be done in the research laboratory and not in the steel plant.

From paper read before fall meeting of the American Iron and Steel Institute.

This fact needs emphasizing as it has sometimes been said, the research laboratory of a steel plant should be the steel plant itself. I believe it will be found, as in this instance, that the plant itself does not, in general, provide the facilities and material adequate for the determination of fundamental constants and properties.

Thus, we spent considerable time in various steel plants trying to determine the radiation characteristics of liquid steel but with unsatisfactory results. The actual determinations were made in the laboratory with an instrument we have devised which is identical in principle with the optical pyrometer above mentioned except that it was a microscope instead of a telescope, and the masses of steel operated upon, instead of being 50 ton heats, were of the order of a few thousandths of a milligram. With the micropyrometer, as we call it, we were able to show that the emissivity of pure iron is 0.37 with light of wave length, λ 0.65 μ (i.e., for red light used with the pyrometer, a free surface of iron radiates only 37 per cent of the same light from a furnace at the same temperature as the iron); furthermore, this quantity ($e = 0.37$) remains constant over the whole temperature range of steel manufacture and is not altered by the presence of any of the elements which may be present in steel and iron, and is also nearly identical with the emissivity of nickel and even, as very recent measurements show, of monel metal and other alloys of iron or nickel so long as they show no change in color caused by alloying. Similar measurements were made for iron oxides in liquid and solid states and of slags. It was then a simple matter to construct correction tables for the pyrometer when sighted on any of the substances.*

As to the mass of data which has been gathered on measurements of steel temperatures by the ever increasing number of observers, it is not my intention to go into detail here. They are available or referred to in the papers of the Chicago symposium. It may, nevertheless, be well to summarize here the present state of the subject.

The pyrometer committee of the National Research Council, among others, has made an extended survey of the possibilities of various methods of measure-

*In steel manufacturing practice it was found advisable to adopt the value 0.40 rather than 0.37 for iron and steel and the correction tables are based on the $e = 0.40$ for $\lambda = 0.65 \mu$, for reasons explained in the Bureau of Standards Technologic Paper 91, published, 1917.

ment of liquid streams of iron, steel and slag and of temperatures in open hearth and electric furnaces.

The question of measuring accurately, most conveniently and practically instantaneously, or to better than 5 degrees at 1,500 degrees C. (2,732 degrees F.) in intervals of 5 to 10 seconds, the temperature of running streams of liquid steel, as in tapping a furnace or teeming ingots, may be said to have been solved some time ago by the use of the optical pyrometer of the modified Morse type, to the readings of which corrections are to be applied based on $e = 0.40$ for $\lambda = 0.65\mu$ when sighting on iron or steel, with similar corrections for liquid iron oxide ($e = 0.53$) and slags ($e = 0.65$ or thereabouts depending somewhat on the nature of the slag). This does not mean that other pyrometers cannot be used successfully for this purpose, for they have been, including other types of optical pyrometer and various total radiation instruments.

It has been demonstrated also that the arch or dome of an open hearth furnace may be watched and its temperature controlled by the same pyrometer, although here no corrections appear to be necessary to the observed temperatures.

Similarly, the temperature of the surface of the slag in an electric or open hearth furnace may be observed through peepholes with doors shut if care is taken to avoid flames and smoke, and the progress of the heat as related to slag temperatures may be followed with considerable accuracy at least for open hearth furnaces.

The most difficult and most important problem is to determine, for any instant of time and condition of bath, the temperature of the metal bath itself. There is, perhaps, some comfort in appreciating that, in general, this difficulty is offset in part by the fact of non-uniformity of temperature within the metal unless the bath is well and frequently stirred. These differences within the bath, as have been shown from a series of observations of tapping temperatures, may reach under certain methods of operating, 200 degrees F. or more and are evidently within the control of the melter.

Considering the apparently crude methods in use, it is a source of wonder to anyone who has had occasion to check the temperatures of steel, as cast, to note the marvelous uniformity attained from one heat to another by the furnace men. For example, the method of timing the appearance of crust in the chill test as often used appears to have no necessary relation to the bath temperature; nevertheless, this remarkable uniformity in casting temperatures extends over the whole steel industry.

The pyrometer committee, above mentioned, made a series of trials of an improved form of the chill test, devised by Mr. Drinker, and were reluctantly forced to the conclusion that reliable estimates of bath temperatures cannot be obtained by this method. All methods, which depend on lifting out metal from the furnace in a spoon, are subject to so many sources

of error and require such rigid exactness of manipulation as to be unsuitable for ordinary practice and of doubtful reliability even when extraordinary care is exercised, although excellent individual observations by such methods have undoubtedly been made.

An elaborate series of experiments was carried out by the committee with various refractory tubes thrust into the metal bath; but, with the exception of Acheson graphite, no material was found satisfactory. In this procedure the optical pyrometer is sighted down the tube on the closed end of graphite immersed in the bath to the desired length. More surveys should be made by this method using graphite tubes. Pieces of graphite or graphite tubes may also be plunged into and held beneath the surface of the bath in electric and open hearth furnaces and then allowed to come to the surface or removed from the furnace entirely, and the temperature of the metal may then be estimated quite accurately in either case from observations taken with the optical pyrometer of the graphite temperatures. No corrections have to be applied to the instrument and this graphite has the further advantage that slag does not stick to it.

The question of following electric furnace temperatures is complicated by the presence of the electrodes but the practice of changing slags gives opportunity for intermittent temperature observations of a satisfactory nature by various methods as shown by Mr. Bash in a paper presented at the Chicago Symposium. The technique of electric furnace temperatures, however, needs considerable additional study. From a comparison of casting temperatures of several electric and open hearth furnaces in normal operations Mr. Bash concludes that electric furnaces are not tapped at higher temperatures than are open hearth furnaces, as is often held.

It would appear that, heretofore, most of the determinations of furnace temperatures have been made by representatives of the research laboratory or instrument maker, and nearly all the published observations were so taken, although there is undoubtedly in existence considerable data and experience accumulated by steel makers themselves. It is evident that discontinuous observations taken somewhat casually by outside parties, although they may serve excellently for demonstration purposes, can nevertheless by no means replace the continuously carried out observations made by representatives of the steel maker himself over long periods of time and under the incessantly changing conditions of practice. In this way alone can the problems of temperature conditions, control and interpretation be solved.

There has been furnished the steel maker for this task, a simple, accurate and convenient pyrometer; the technique surrounding the taking of steel furnace temperatures has been sufficiently, if not definitely, worked out; and there have been determined all the fundamental physical constants necessary for transposing the observational readings into actual temperatures. The steel maker himself will have to solve the rest of the problem.

Electric, Open Hearth and Bessemer Steel Temperature Measurements

Mean Temperatures from Blast Furnace to Finished Steel.
Tapping Temperatures of Steel—Curves Showing Temperatures
in Triplex Process—Data for Various Kinds of Steel.

By F. E. BASH.*

Whenever electric and open hearth steel men discuss the relative advantages of their respective methods, the question of temperature is always discussed, so that this paper is written in the hope that definite data may settle some of the questions and encourage further investigations along these lines. The writer has had the opportunity of taking the tapping temperatures of steel from electric furnaces of different sizes in various plants and from a number of open

in which E = emissivity; $C_2 = 14,500$; e = base of Napierien logarithms; λ = wave-length of light used = 0.65μ ; T_2 = true temperature, in degrees absolute; T_1 = apparent temperature, in degrees absolute. The curve showing the relation between true and apparent temperature for steel and slag are given in Fig. 1.

For the purpose of comparison of open hearth and electric furnaces, there are given in Table 1 the tapping temperatures of two 25-ton Heroult electric furnaces and one 6-ton, with one 50-ton acid, one 40-ton basic, and one 65-ton acid open hearth furnace, all making nickel ordnance steel for guns. The two 25-ton Heroult electric furnaces were finishing steel refined by the triplex process and the 6-ton Heroult finished steel that was partly refined in an open hearth. In this table, the tapping temperature and the temperature of the steel stream into the first ingot mold are given together with the mean of each column. The values for each plant are the average for a number of heats.

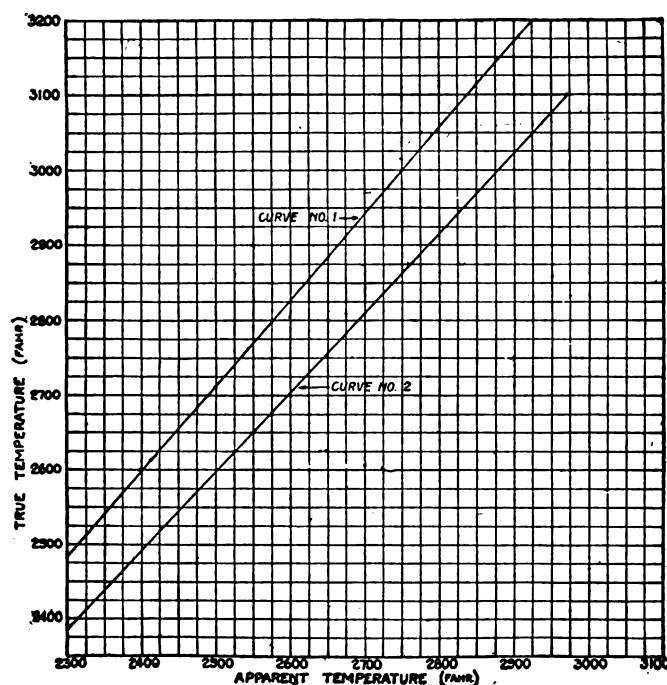


Fig. 1—Emissivity Corrections for Steel and Slag.
Curve 1—Steel. Curve 2—Slag.

hearths handling the same kind of steel. All temperature measurements were made with the same disappearing-filament type optical pyrometer and the corrections for emissivity applied were those worked out by Burgess† which are 0.40 for steel streams and 0.65 for slag. The correction is applied by calculating the curve giving the relation between the true and apparent temperature in the following formula:

$$\log E = \frac{C_2 \log e}{\lambda} \left\{ \frac{1}{T_2} - \frac{1}{T_1} \right\}$$

* From paper read before September, 1919, meeting of A. I. M. and M. E., Chicago.

† Temperature Measurements in Bessemer and Open Hearth Practice. U. S. Bureau of Standards Tech. Paper 91 (1917).

Table 1—Tapping Temperatures of Steel.

Steel Co.	Tapping First Temp. Ingot, Deg. Deg.		Type of Furnace
	F.	F.	
A	2867	2744	25-ton Heroult electric.
B	2821	2745	6-ton Heroult electric.
B	2821	2721	6-ton Heroult electric.
C	2842	2768	50-ton open hearth, acid.
D	2877	2753	40-ton open hearth, basic.
E	2895	2794	65-ton open hearth, acid.
Mean.....	2854	2754	
Mean for electric fur- naces.....	2836	2737	
Mean for open-hearth furnaces.....	2871	2772	

The table shows how closely the temperatures agree from plant to plant and in the different types of furnaces. The greatest variation in tapping temperatures, between B and C, is only 74 degrees F. (24 degrees C.) while the average for all the electric furnaces is 35 degrees F. lower than for the open hearths, although it is generally thought that open hearth steel is tapped colder than electric.

The drop in temperature from the tap to the first ingot depends on the length of time the steel is held in the ladle, the size of nozzle, size and preliminary temperature of the ladle, and various other factors. It is interesting to note, however, that the mean drop in temperature of the steel from tapping to first ingot for both the electric and the open hearth furnace is 100 degrees F.

In Table 2 is given a tabulation of temperature data

taken on two electric furnaces making nickel ordnance steel. At the time these temperatures were taken, the ingots were box poured so that temperature observations were made on the stream above and below the box on the first ingot and below the box on all subsequent ingots. Since there was no satisfactory method of taking temperature of the steel in the furnace, a chill test was made by taking out a small spoon of steel and noting the time required for a crust to form over the surface of the metal therein. These time values are also given.

Table 2—Summary of Temperatures for Nickel Gun Steel. First Ingot

Heat No.	Tap Temperature, Degrees F.	Over Box, Degrees F.	Under Box, Degrees F.	Second Ingot, Degrees F.	Third Ingot, Degrees F.	Chill Test, Seconds	Time Held in Ladle, Minutes
3 X 707	2895	2793	2737	2722	2705	8	
3 X 710	2880	2842	2790	2797	2770	26	5½
3 X 711	2850	2761	2730	2747	2761	37	5
3 X 715	2917	2843	2768			40	8
3 X 719	2830	2805	2737			31	6
3 X 723	2805	2745	2720	2680		35	5½
4 X 651	2872		2761	2752	2728	38	7
4 X 659	2865		2797	2745	2761	33	8
4 X 666	2872	2813	2768	2730		27	5
3 X 727	2835	2775	2705	2680	2697	?	7
2 X 3146	2910		2730	2730	2730		
Mean	2867	2797	2744	2732	2736	33.5	6.5

It will be noted that the tapping temperatures vary from 2805 degrees to 2917 degrees, F. (1540 to 1603 degrees C.) but that most of them are within + or - 30 degrees F. of the mean. It will also be noted that the temperature of the steel stream into the second ingot mold is a little higher, on an average, than that into the first ingot mold. The reason for this is obvious as the metal lying next to the bottom of the ladle is colder than the main mass of the molten steel. Similar variations will be noted in taking measurements on the tapping stream from a furnace, as the metal in different parts of the hearth often varies 25 degrees to 30 degrees F. in temperature.

In an effort to find the relation between the tapping temperature of the steel and the time of the chill test, the respective values were plotted on a curve sheet with the result shown in Fig. 2. The curve is anything but a smooth one and shows how unreliable the chill-test method of judging temperatures is. In spite of all care in attempting to draw out the spoon in the same manner each time, the atmospheric conditions, room temperature, and other variables have an influence on the time required for the crust to form.

In Table 3 are given some temperatures taken on manganese and manganese helmet steel. The observations in this case were difficult to make for the reason that heavy clouds of smoke were given off from the manganese so that the readings had to be made from the windward side and a moment chosen for making the reading when the stream was unobscured. The manganese was melted in a 15-ton Heroult furnace and tapped into a ladle which was then transferred to the open hearth plant where the manganese was

poured into the steel ladle at the time that the steel was tapped.

Table 3.

Time, P. M.	Temp. Degrees F.	Remarks
6:04	2790	Tap manganese from 15-ton Heroult furnace.
6:30	2822	Tap open hearth furnace.
6:32	2549	Pour manganese in steel ladle.
6:34	2840	Tap open hearth furnace.
6:44	2605	First ingot manganese steel.
6:45	2605	Second ingot manganese steel.
6:47	2647	Third ingot manganese steel.

An opportunity was presented to take temperatures on steel made by the triplex process, so at the same time blast furnace tapping temperatures were taken and a record made from the blast furnace to the steel ingot. The practice was to take the molten pig iron to a mixer from which it went to a Bessemer converter, thence to an open hearth furnace, and finally to an electric furnace for finishing. The mean of readings taken on each operation are set down in Table 4. The value for the Bessemer tap is the mean for 10 heats and that for the electric furnace is for 11 heats.

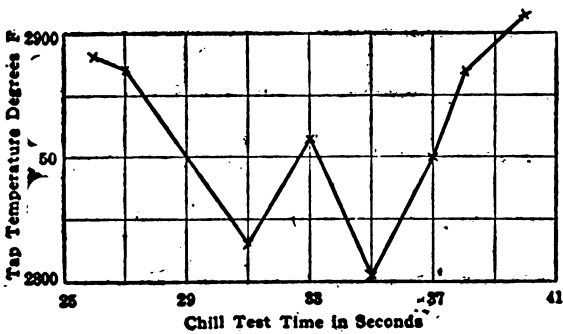


Fig. 2.

Table 4—Mean Temperatures from Blast Furnace to Finished Steel.

	Temperature, Degrees F.	Remarks
1	2625	Mean of metal streams into ladles from blast furnace.
2	2485	Mixer metal charged into Bessemer.
3	2909	Bessemer tap.
4	2797	Charge Bessemer steel to open hearth furnace.
5	2902	Tap open hearth furnace.
6	2872	Charge electric furnace.
7	2867	Mean electric-furnace tap.
8	2797	First ingot pour above box.
9	2744	First ingot pour under box.
10	2732	Second ingot pour under box.
11	2736	Third ingot pour under box.

	Temperature, Degrees F.	Temperature Differences
1	100	Temperature drop from Bessemer tap to open hearth charge.
2	25	Temperature drop from open hearth tap to electric furnace charge.
3	70	Temperature drop from tap of electric furnace to stream from ladle for first ingot for average of 6½ min. in ladle.
4	55	Temperature drop through box.

In Fig. 3, the data in this table is presented graphically. The great increase in temperature in the Bessemer converter and other temperature relations are distinctly brought out.

In Table 5 is given data on tapping and teeming for three open hearth furnaces in different plants making nickel ordnance steel and one making shell steel.

Six 26-inch octagon ingots were poured with large end up, each ingot was individually bottom poured from the 40-ton basic open hearth furnace. One 63-inch, 85-ton octagon ingot was poured and a number of 23-inch octagons were poured from two 65-ton open hearth furnaces that were tapped simultaneously and poured consecutively.

Table 5—Open Hearth Steel Temperatures on Nickel Ordnance Steel.

Time	Temperature, Degrees F.	Remarks
50-ton Acid Open Hearth Furnace.		
11:55	2842	Tap steel.
		Held 10 min. in ladle.
12:12	2768	Four ingots bottom poured in sets of two.
12:19	2768	Pour first two ingots.
		Pour second two ingots.
40-ton Basic Open Hearth Furnace.		
4:10	2877	Tap steel.
4:21	2713	First ingot.
4:22	2722	Tong hold.
	2753	Second ingot.
	2722	Second ingot.
	2722	Third ingot.
	2705	Third ingot.
	2713	Fourth ingot.
65-ton Acid Open Hearth Furnace.		
8:33	2895	Tap one furnace. Other tap not recorded
8:43	2835	Stream from ladle to runner.
8:44	2843	Stream from ladle to runner.
8:47	2768	Stream into headbox.
8:47½	2737	Stream into headbox.
8:48	2688	Stream from headbox.
8:51	2761	Stream into headbox.
8:56	2761	Stream into headbox.
Second Ladle.		
9:00	2753	Stream into headbox.
9:01	2761	Stream into headbox.
9:04	2761	Stream into headbox.
9:06	2745	Stream into headbox.
9:09	2737	Stream into headbox.
9:12	2768	Stream into headbox.
9:20	2745	Stream for four 23-in. octagons.
9:21	2620	Steel rising in mold one-third full. Light smoke.
9:22	2782	Stream to group of 23 inch octagons.
9:25	2813	Stream to group of 23 inch octagons.
9:29	2828	Stream to group of 23 inch octagons.
9:30	2745	Stream to group, dark streak, good
65-ton Acid Open Hearth Furnace, Nickel Chromium Steel.		
1:37	2879	Tap steel.
	2895	Tap steel.
	2910	Tap steel.
Teem		
1:44	2835	First group (8 tons to a group, four ingots).
1:45	2828	First group.
1:49	2835	Second group.
1:55	2790	Fifth group.
2:01	2775	Sixth group.
2:03	2753	Seventh group.

NOTE—Acid furnace on shells, 3-in. nozzle. carbon, 0.60; chromium. 2.25; nickel 3.5.

Beside the temperature measurements on nickel ordnance steel, a number of readings were made on different types of steel in two 10-ton Ludlum electric furnaces. These were taken through the courtesy of P. A. E. Armstrong, vice president of the Ludlum Steel Company. The practice was to refine with two or three slags so that it was possible to take readings on the oxidized surface of the molten steel during the skimming and also to get readings on thin slag patches floating on the metal. It was found that readings on the slag patches corrected for an emissivity of 0.65

almost exactly agreed with uncorrected readings on the iron oxide adjacent. In other words, if the radiation from the oxide in the furnace with the arc off and the door open is that of a black body, then the emissivity of slag is approximately 0.65, as stated by Burgess. In Table 6 are given a number of readings on different skims made in this manner. It will be noted that the mean values for the two columns agree exactly with each other. If the emissivity of slag is 0.65, then the iron oxide under the above conditions must give black-body radiation for red light.

Table 6—Summary of Data on Slag Skimming.		
Optical Reading on Slag Patch Corrected,* Deg. F.	Optical Reading on Iron Oxide, Degrees F.	Remarks
2611	2618	H. S.
2621	2629	X1C.
2611	2618	C.S.
2718	2709	C. S.—refractory slag.
2628	2618	C. S.
2532	2562	C. S.—cold
2728	2694	C. S.—same heated.
Mean 2636	2636	

In Table 7 is given a summary of data taken on tapping and teeming a number of heats. The steel was tapped or poured from the furnace into two ladles and then very quickly teemed into ingot molds.

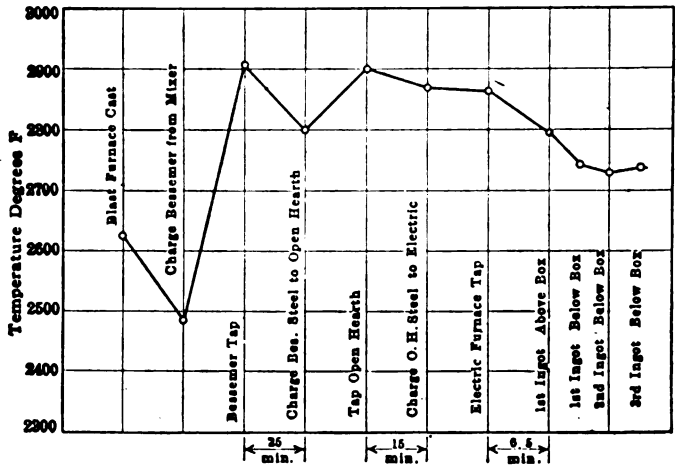


Fig. 3—Temperatures in Triplex Process.

In order to make sure of the steel temperature in the furnace, a Dixon graphite tube 4 feet (1.2 m.) long by 4 inches (10 cm.) outside diameter with a closed end, was pushed into the steel and held there until the end had come to temperature, at which time a reading was made with the optical pyrometer sighted down the axis on the inside of the closed end, which was in the steel. Under these conditions, the reading in the tube should give the true temperature of the steel. One such reading was taken just before a tap and is recorded in the table. It is only 17 degrees F. below the temperature read on the steel stream, which is a very good agreement. Readings made on the slag surface in the furnace before the tap do not agree so well with readings on the stream, as is also shown.

Further readings in a graphite tube were made at another time. The arc had been off for about 10 minutes and the door was opened just sufficiently to allow the tube to be inserted. A reading was made

*Burgess' value of 0.65 for emissivity of slag used.

Table 7—Summary of Ludlum Temperature Data.

	Temperature in Furnace, Degrees F.	Reading on Steel Tapping Corrected, Degrees F.	Reading on Slag Tapping Corrected, Degrees F.	First Ingot, Degrees F.	Last Ingot, Degrees F.	Remarks
Arc off, slag	2815	2797	2792	2746	2640	First ladle—C.S.
		2737	2770	2746	2625	Second ladle—C.S.
		2686	2652	2700	2625	First ladle—XIC.
				2670	2597	Second ladle—XIC.
Arc off, slag	2789	2730	2711	2653	2580	First ladle—C.S.
		2686	2675	2617	2550	Second ladle—C.S.
Tube	2673	2690	2650	2650		First ladle—C.S.
		2633	2646			Second ladle—C.S.
		2716		2677	2597	First ladle—XIC.
		2677		2637	2620	Second ladle—XIC.
		2790		2723	2662	First ladle—H.S.
		2759	2751	2651	2661	Second ladle—H.S.
Arc (slag) on	2946	2745		2732	2699	First ladle—XIC.
		2717		2692	2611	Second ladle—XIC.

- Degrees F.
- Mean drop from tapping temperature to first ingot (max. 108°, min. 13°)..... 36
 - Mean drop from first to last ingot, for 5-ton ladle..... 62
 - Mean temperature for first ladle tap..... 2743
 - Mean temperature for second ladle tap..... 2704
 - Mean difference between first and second ladles.. 39

Table 8.

Temperature Read, Degrees F.	Remarks
2580	On slag surface, arc off 10 min.*
2606	In closed-end tube, immersed 4 in.
2650	In closed-end tube, immersed 4 in.
2629	Slag surface, arc off.†
2618	Tube in slag.

Table 9—Carbon Steel for Castings.

Time from Start of Tap	Temp. Degrees F.	Remarks
Min. Sec.		
17	2960	On slag tapping.
28	2920	On slag tapping.
46	2982	On slag tapping.
64	2952	On slag finish tapping.
2 30	....	Started to skim.
3 45	....	Finished skimming.
4 45	....	Finished weighing.
5 22	2887	First shank.
7 30	2865	Second shank.
8 20	2821	Pouring second shank into small mold.
9 13	2835	Third shank.
9 53	2797	Pouring third shank into mold
10 9	2797	Pouring third shank into mold.
10 46	2828	Fourth shank.
11 5	2782	Pouring fourth shank into mold.
11 43	2775	Pouring fourth shank into mold.
12 10	2835	Fifth shank.
12 35	2761	Pouring fifth shank.
13 59	2775	Pouring from ladle into first mold.
14 41	2730	Pouring from ladle into second mold.
15 15	2688	Third mold, small stream.
16 3	2782	Fourth mold, large stream.
16 21	2768	Fourth mold.
16 41	2761	Fourth mold.
16 52	2753	Fourth mold.
17 12	2761	Fourth mold, oxidized stream.
18 19	2753	Fifth mold.
20 3	2797	Sixth mold, oxidized stream
21 2	2745	Seventh mold.

on the thin slag surface beside the tube and then in the tube at two different depths, which were calculated

*Slag was approximately $\frac{1}{4}$ in. thick.

†Reading made at a later date than one above.

from measurements of depth of immersion of the tube. The readings are given in Table 8 and are plotted in Fig. 4; they show the temperature gradient of the steel bath from the surface to a 9 inch (23cm.) depth. The top was cooler due to the fact that the arc had been off for a few minutes. This also seems to show that a reading made on a thin slag surface in a furnace that is enclosed, with the arc off, gives true temperatures.

At this point the writer wishes to state that the steel poured from these electric furnaces was the coldest of any he has had occasion to take temperatures on, either open hearth or electric, and further contradicts any supposition that electric steel is hotter than open hearth, at least when it is tapped, although it may be hotter during the refining period.

In Tables 9 and 10, temperatures are given for tapping and teeming a 3-ton basic Heroult furnace. The steel was used for castings and for that reason had to be hotter than steel for large ingots. The temperatures given in Table 10 for tapping manganese steel are the hottest of any electric steel the writer has had occasion to make measurements on. However, it is not hotter than open hearth steel for castings or Bessemer steel for the same purpose, as may be seen by examination of Table 11.

In Tables 9 and 10 it will be noted that there is some fluctuation in the teeming temperatures. This is due to the fact that the steel was poured over the tip of the ladle and was sometimes large and sometimes small. The small stream cooled much more rapidly and as a consequence a lower temperature was read.

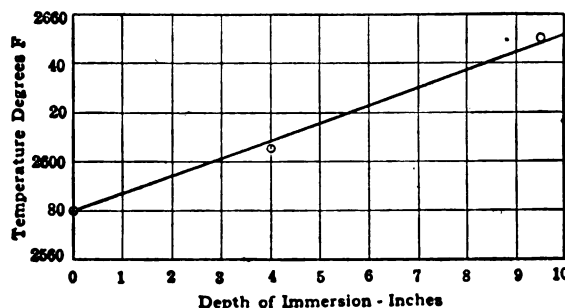


Fig. 4.

Table 10—Manganese Steel for Castings.

Time from Start of Tap	Temperature, Degrees F.	Remarks
Minutes	Seconds	
	15	3053 Steel stream.
	34	3025 Steel stream.
	52	3025 Steel stream.
1	14	3037 Steel stream.
1	38	3025 Steel stream.

Table 11—Temperature Observations on 3-ton Acid Bessemer Converter.

Time	Temperature, Degrees F.	Remarks
2:07	2433	Charging Bessemer on stream
Time after Start of Blow		
Minutes	Seconds	
2	50	2574 Flame from Bessemer.
3	10	2632 Flame from Bessemer.
3	37	2722 Flame from Bessemer.
4	10	2824 Flame from Bessemer.
5	12	2860 Flame from Bessemer.
6	43	2747 Flame from Bessemer.
7	18	2752 Flame from Bessemer.
8	0	2527 Ferromanganese into ladle.
9	32	3060 Tap Bessemer.
11	53	Finish tap.

Pyrometry in the Blast Furnace Plant

Relation Between the Temperature in the Furnace Hearth and the Analysis of the Metal—Results of Tests Made on Blast Furnaces.

By P. H. ROYSTER and T. L. JOSEPH.

It was the writer's purpose in making the temperature measurements reported in this paper to establish, on as definite a quantitative basis as possible, the relation between the temperature in the furnace hearth and the analysis of the metal made. The silicon-sulphur theorem is unfortunately rather indefinite. The silicon, for example, is alleged to depend not only on the temperature but also on the slag composition and volume, the size of the furnace, the tonnage made per day, and the character of the charge. These factors are in doubt in that each can mean one or more of several things. The temperature of the hearth may mean the temperature of the metal or of the slag in the hearth, or it may mean the temperature of the solid stock in the combustion zone or of the products of combustion arising from that zone. By the composition of the slag one usually means its "basicity." This again doesn't mean anything in particular; it may refer to the percentage of limit or of bases, or to the ratio of lime to silica, of bases to silica, of lime to acids, or of bases to acids. The size of the furnace may mean its hearth diameter, its bosh diameter, or its volume; the "character of the stock" may mean anything. In order successfully to correlate the temperature measurements obtained at the several furnaces, therefore, it was necessary at the same time to secure all the information available concerning both the furnaces and the furnace practice.

Temperature Measurements and Operating Data From Iron Blast Furnace Operation.

A summary of the temperature measurements made by the writers and some of the operating data obtained from the furnace records for 20 iron furnaces are given in Table 1. The furnaces are numbered arbitrarily from 1 to 20, as shown in the first column. Temperatures measured with a set of Morse type optical pyrometers are given in the second, third, and fourth columns. Under the caption Tuyere Temperatures are given the temperature readings observed when the pyrometer was sighted through the tuyere stock and along the axis of the blowpipe, through the tuyere and into the furnace. These temperatures are corrected, as well as was practicable, for the absorption of the glass screen in the tuyere sight. The slag and metal temperatures are those observed when the pyrometer was sighted on the surface of the slag and metal streams in their respective runners at flush and at cast. To the observed readings has been applied an appropriate emissivity correction. The details of the measurements and their probable accuracy will be dis-

cussed later. The metal and slag analyses were made by the companies' chemists. The figures in the last four columns were taken from the furnace records and have their usual significance. The fuel consumption is given in terms of pounds of carbon in place of the usual pounds of coke per ton of metal.

Comparison of Silicon-Sulphur Pyrometer With Optical Pyrometer.

A casual examination of the figures in Table 1 reveals little to support the theorem that the temperature of the furnace can be determined from the silicon or sulphur in the metal or from any simple relation based on metal and slag analyses. The silicon varies from 0.92 to 2.40 per cent, the tuyere temperature from 1,595 degrees to 1,862 degrees C. (2,903 degrees to 3,384 degrees F.), the slag temperature from 1,437 degrees to 1,543 degrees C. (2,619 degrees to 2,809 degrees F.), and the metal temperature from 1,426 degrees to 1,473 degrees C. (2,599 degrees to 2,683 degrees F.). The range of variation found in this limited number of furnaces is: silicon, 1.48 per cent, tuyere temperature 267 degrees C., slag temperature 106 degrees, and metal temperature 47 degrees. The silicon in the hottest metal is 1.14 per cent and in the coldest metal 1.05 per cent; the silicon in the metal corresponding to the hottest slag is 1.70 per cent, and in the metal accompanying the coldest slag it is 1.05. The metal made by the furnace having the highest tuyere temperature carries 1.27 per cent silicon. The furnace showing the coldest tuyeres, however, made metal with the lowest silicon; that is, furnace 9, tuyere temperature 1,595 degrees and silicon 0.92 per cent.

The 20 furnaces were arranged in the order of the increasing silicon content of the metal and were divided into four groups. The operating quantities for these furnaces were averaged by groups and the results are shown in Table 2. It is rather difficult to establish any basis for the silicon-sulphur theorem from these data. The three temperatures that might possibly indicate hearth temperature are included in this table as well as the three expressions that might indicate the basicity of the slag; for the most part none of these six quantities vary markedly with the silicon in the metal. Group I has average basicity and a high hearth temperature; group IV has average hearth temperature and a low basicity; groups II and III have both average hearth temperature and average basicity.

In order to look at these data in the other direction, the furnaces were rearranged in the order of decreasing tuyere temperatures, and averaged in four groups. The results of this arrangement, as is given in Table 3,

From paper read before September, 1919, meeting of A. I. M. and M. E., Chicago.

Table 1—Operating Data From Twenty Furnaces.

Fur. No.	Temperature, Degrees C.		Metal Analysis				Slag Analysis				Blast Temperature, Degrees C.	Pounds of Carbon per Ton of Metal	Pounds of Slag per Ton of Metal	Tons of Metal per Sq. Ft. of Hearth Area
	Tuyere	Slag	Si	S	Mn	P	CaO	MgO	Al ₂ O ₃	SiO ₂				
1	1643	1526	1463	2.40	0.033	0.56	0.081	41.5	3.1	17.6	35.0	1.58		
2	1629	1524	1467	1.99	0.025	0.62	0.080	42.5	3.1	16.6	35.4	1.77		
3	1627	1530	1462	1.97	0.026	0.71	0.082	43.0	3.1	16.4	35.0	1.77		
4	1648	1506	1470	1.32	0.034	0.33	0.089	46.3	3.5	13.0	35.9	1.60		
5	....	1473	1443	1.09	0.036	0.56	0.208	46.3	3.5	13.3	35.4	1.62		
6	1649	1531	1426	1.05	0.044	0.32	0.094	46.7	3.5	11.8	37.2	1.53		
7	1648	1473	1444	1.51	0.035	0.68	0.100	48.5	2.0	13.1	34.9	1.62	1150	2090
8	1640	1451	1437	1.29	0.049	0.65	0.096	48.3	2.2	13.0	35.0	1.74	1025	1765
9	1595	1437	1437	0.96	0.049	1.62	0.206	46.1	3.5	14.7	34.0	1.81	1000	1545
10	1656	1449	1456	1.37	0.031	0.71	0.084	46.5	2.3	15.7	32.6	1.30	980	1645
11	1802	1469	1467	1.42	0.024	1.30	0.233	47.5	2.0	16.3	31.1	1.59	933	1678
12	1710	1493	1454	1.14	0.030	0.73	0.084	46.5	2.2	15.4	33.7	1.22	950	1631
13	1700	1511	1473	1.14	0.020	1.73	0.350	45.0	6.2	11.9	35.3	1.38	1150	1685
14	1731	1481	1437	1.08	0.036	1.90	0.315	43.9	6.0	12.5	36.0	1.33	837	1720
15	1862	1514	1468	1.27	0.034	1.34	0.131	43.0	2.3	17.4	34.2	1.43	1006	1518
16	1821	1528	1459	1.59	0.032	0.80	0.085	38.9	7.3	15.5	36.0	1.70	1105	1502
17	1849	1543	1471	1.70	0.041	0.71	0.084	36.5	7.1	16.0	37.1	1.83	944	1720
18	1800	1525	1471	1.76	0.029	0.76	0.084	37.3	7.3	16.6	36.6	1.84	971	1629
19	1712	1499	1463	1.57	0.040	....	....	39.4	9.5	15.5	32.4	....	1025	1845
20	1668	1501	1448	0.97	0.032	....	....	42.5	9.4	12.8	33.0	....	758	1641

Table 2—Furnaces Grouped According to Silicon Content.

Group	I	II	III	IV
Furnaces included	5, 6, 9, 14, 20	4, 8, 12, 13, 15	7, 10, 11, 16, 19	1, 2, 3, 14, 20
Silicon in metal	1.02	1.23	1.49	1.96
Sulphur in metal	0.038	0.034	0.033	0.031
Tuyere temperature, deg. C.	1656	1720	1732	1737
Slag temperature, deg. C.	1498	1505	1493	1539
Metal temperature, deg. C.	1448	1470	1468	1477
CaO/SiO ₂	1.28	1.31	1.33	1.12
CaO + MgO/SiO ₂	1.39	1.41	1.47	1.25
CaO + MgO/SiO ₂ + Al ₂ O ₃	1.04	1.01	1.01	0.86
Viscosity of slag	480	814	1048	690

Table 3—Furnaces Grouped According to Tuyere Temperatures.

Group	V	VI	VII	VIII
Furnaces included	11, 15, 16, 17, 18	12, 13, 14, 19, 20	1, 4, 6, 10	2, 3, 8, 9
Tuyere temperature, deg. C.	1827	1704	1649	1623
Slag temperature, deg. C.	1516	1497	1497	1491
Metal temperature, deg. C.	1467	1455	1452	1450
Silicon in metal	1.55	1.18	1.48	1.59
Slag temperature minus metal temperature, deg. C.	49	42	45	41

show that the slag is quite uniformly 45 degrees hotter than the metal and that the metal temperature is quite closely proportional to the tuyere temperatures, the metal temperature rising 8 degrees for every 100 degrees increase in tuyere temperature. In this case group IV, with the coldest hearth, shows the highest silicon.

Calculation of Silicon in Metal.

With the aid of more or less complete data on a number of furnaces, it is usually impossible to miss a relation existing between the various quantities once preconceived theories have been discarded. In the present case it can be shown that the silicon in the metal can be calculated from the following equation with an average error of 10 points of silicon and a maximum error of 20 points.

- If S = per cent of silicon in metal;
 t = temperature of slag, degrees C.;
 T = tons of metal made in 24 hr.;
 D = hearth diameter, in feet;
 F = pounds of coke per ton of metal;
 M = per cent of silica in the coke.

then

$$S = \frac{FM}{47.7} \left[0.238 + 0.143 \frac{T}{D^2} + 0.0012 (t - 1500) \right] \quad (1)$$

There are insufficient data from the first six furnaces to enable one to compare the actual results with the equation. For the remaining 14 furnaces sufficient data of sorts are available, and the silicon has been calculated from this equation; the results are shown in Table 4.

Table 4—Calculated Silicon Contents.

Fur. No.	Silicon, Actual, Per Cent	Silicon, Calculated, Per Cent	Difference, Per Cent	Fur. No.	Silicon, Actual, Per Cent	Silicon, Calculated, Per Cent	Difference, Per Cent
7	1.51	1.58	— 7	14	1.08	1.03	5
8	1.29	1.21	8	15	1.27	1.36	— 9
9	0.96	1.07	— 11	16	1.59	1.45	14
10	1.37	1.26	11	17	1.70	1.61	9
11	1.42	1.26	16	18	1.76	1.57	19
12	1.14	1.24	— 10	19	1.57	1.46	11
13	1.14	1.19	— 5	20	0.97	1.01	— 4

In Fig. 1 the calculated and the actual values of the silicon are shown diagrammatically. It is rather difficult to attribute the agreement solely to coincidence; in fact, it is definitely evident from Table 4 and Fig. 1 that the equation is an approximation of the true relation. It must not be concluded, however, that the equation can give the answer to the problem with any finality. It can be regarded as nothing more than the best quantitative expression that has so far been offered for predicting the silicon in the metal.

The interpretation of the equation 1 is rather simple. FM is the pounds of silica per ton of metal in the form of coke ash. This quantity, divided by 47.7, silica required to produce the silicon in the average metal, for these 14 furnaces, is about 54 per cent of the silica in the coke ash. The values for the individual furnaces vary from 47.4 to 66.5 per cent. The furnace "recovers" therefore something better than 50 per cent of the silicon in the coke ash. This silicon recovery varies largely, and almost exclusively, with the tons of metal made per square foot of hearth area. In addition, but to a much less important extent, it varies

with the temperature of the slag. An increase of 100 degrees in slag temperature increases the silicon about 0.06 per cent. Since the silicon is thus so slightly affected by the slag temperature, it is obviously impossible practically to determine the slag temperature from the silicon in the metal. It is scarcely within the scope of the present paper to discuss this problem further; although the question of silicon control may be of importance to the general problem of furnace operation and control, the sole reason for considering it here was to show that it is but a slight indication of the hearth temperature theoretically and that practically it is no indication at all.

Furnaces have been operated many years on the assumption that the silicon in the metal is a hearth thermometer, and it is undeniable that a cold furnace (i.e., a furnace producing low-silicon metal) can be cured by increasing the coke charge per ton of metal. Equation 1 shows that the silicon can be raised by increasing the coke consumption, by virtue of the fact that such an increase in coke consumption increases the amount of silicon in the coke ash, quite independent of any change it might produce in the temperature of the hearth.

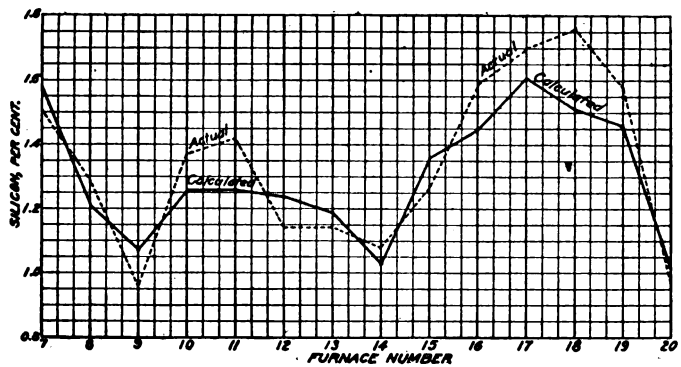


Fig. 1.

Sulphur in the Metal as a Pyrometer.

If s = per cent sulphur in metal;
 S = per cent sulphur in slag;
 t = temperature of metal, in degrees centigrade;
 B = ratio $\text{CaO} + \text{MgO} \div \text{Al}_2\text{O}_3 + \text{SiO}_2$

it can be shown that the empirical equation $s = 0.074 + 0.0183 S - 0.00061 (t - 1400) - 0.037 B$ (2) agrees with the facts shown in Table 1 within an average error of 0.0045 per cent sulphur. Unlike the expression found for the silicon in the metal, this relation between sulphur and the related operating quantities agrees in a general way with the usual ideas held by furnacemen. The values of the actual sulphur and of the calculated sulphur in the metal for the first 18 furnaces are given in Table 5 and are shown diagrammatically in Fig. 2.

The sulphur is lowered by increasing the ratio of bases to acids, by raising the temperature of the metal, and by lowering the sulphur in the slag. This is the old story of sulphur control but for the first time in quantitative form, and substantiated by a certain amount of proof. The ratio of bases to acids is used as an independent variable here merely because it gives more concordant results than the ratio either of bases

to silica, or of lime to silica. In the same way the temperature of the metal is used in preference to the temperature either of the slag or of the tuyeres, because the agreement is better. It must be remembered that both equations one and two are offered merely as empirical equations found by trial to agree with the observed facts with the consistency shown in Figs. 1 and 2. There will be ample time to theorize about these relations when their truth has been satisfactorily established. It may be of interest to notice, however, that of the three proposed expressions for the "basicity" of the slag the ratio of bases to acids seems to be the most significant.

Determining Metal Temperature Without Pyrometric Measurement.

The sharply defined effect of metal temperature on the sulphur in the metal suggests immediately the use of equation 2 for determining this temperature. If the equation is rewritten

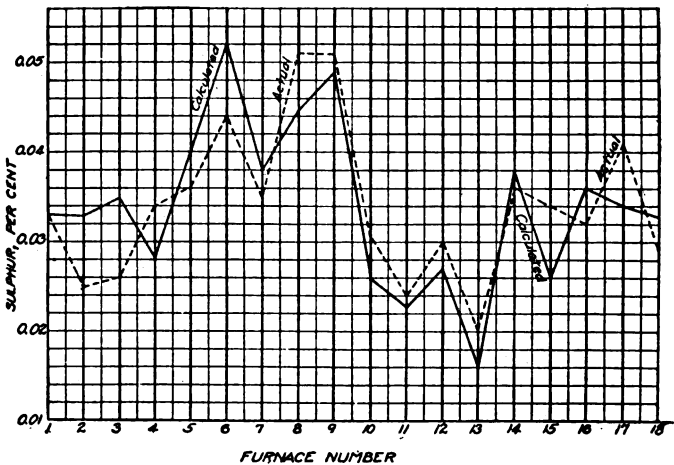


Fig. 2.

$$t = 1521 + 30 S - 61 B - 1666 s \quad (3)$$

the temperature of the metal can be directly computed. Since from Table 3 the slag temperature averages 45 degrees hotter than the metal an approximation to the slag temperature can also be made. This has been

Table 5—Calculated Sulphur Content.

Furnace Number	Sulphur, Actual Per Cent	Sulphur, Calculated Per Cent	Difference Per Cent
1	0.033	0.033	0.000
2	0.025	0.033	-0.008
3	0.026	0.035	-0.009
4	0.034	0.028	+0.006
5	0.036	0.040	-0.004
6	0.044	0.050	-0.006
7	0.035	0.038	-0.003
8	0.049	0.045	+0.004
9	0.049	0.047	+0.002
10	0.031	0.026	+0.005
11	0.024	0.023	+0.001
12	0.030	0.027	+0.003
13	0.020	0.016	+0.004
14	0.036	0.038	-0.002
15	0.034	0.026	+0.008
16	0.032	0.036	-0.004
17	0.041	0.034	+0.007
18	0.029	0.033	-0.004

done and the results are given in Table 6. It is observed that the maximum discrepancy between the

observed and the calculated temperatures is 16 degrees and that the average discrepancy is 7.4 degrees. As the calculated value involves all the errors in chemical analyses for S in the metal, and for CaO, MgO, Al_2O_3 , SiO_2 , and S in the slag, the agreement is remarkably close. Moreover, as will be mentioned later, the uncertainty in the pyrometer readings on the metal is easily 7 degrees. For any ordinary purpose, calculation gives perfectly satisfactory metal temperatures but the calculated slag temperatures may be 50 degrees in error; the average error for slag temperature is 19.5 degrees. As was shown by Table 3, a change of 8 degrees corresponds, in a general sort of way, with a 100 degrees change in tuyere temperature. Hence it would be expected, and it is found to be true, that an attempt to trace back from the sulphur in the metal to the tuyere temperature fails.

Conclusions Concerning Relations Between Silicon, Sulphur, and Hearth Temperature.

The facts presented and discussed above appear to a point to a number of conclusions many of which are quite contrary to what has heretofore been accepted, and which may be of importance to furnace operators. In summary form they may be stated:

Table 6—Calculated Metal and Slag Temperatures.

Furnace Number	Metal Temperature, Deg. C.			Slag Temperature, Deg. C.		
	Actual	Calculated	Difference	Actual	Calculated	Difference
1	1463	1463	0	1526	1508	+18
2	1467	1480	-13	1524	1525	-1
3	1462	1478	-16	1530	1523	+7
4	1470	1459	+11	1506	1504	+2
5	1443	1449	-6	1473	1494	-21
6	1426	1436	-10	1531	1481	+50
7	1444	1448	-4	1473	1492	-19
8	1437	1430	+7	1451	1474	-23
9	1437	1434	+3	1437	1479	-44
10	1456	1448	+8	1449	1494	-46
11	1467	1466	+1	1469	1511	-42
12	1454	1449	+5	1493	1494	-1
13	1473	1464	+9	1511	1509	+2
14	1437	1441	-4	1481	1486	-5
15	1468	1456	+12	1514	1501	+13
16	1459	1465	-6	1528	1510	-18
17	1471	1459	+12	1543	1504	-39
18	1471	1477	-6	1525	1522	+3

1. The silicon in the metal is not dependent on the chemical composition of the slag; the temperature of the hearth; the silica content of the ore; the viscosity of the slag; the blast temperature.

2. The silicon in the metal is dependent on the silica in the coke ash; the speed of operations expressed as tons of metal per day per square foot of hearth area; the slag temperature, but to an almost negligible extent.

3. It is impossible, practically, to estimate the temperature of the combustion zone, of the metal, or of the slag from any simple expression involving the silicon content of the metal.

4. The sulphur in the metal is not, in general, lower with high silicon metal.

5. The sulphur in the metal is dependent on the sulphur in the slag; the temperature of the metal; the ratio of bases to acid.

6. The temperature of the metal can be calculated from the sulphur in the slag, the sulphur in the metal, and the ratio of bases to acids in the slag. The maxi-

mum error in this calculation is 16 degrees C. and the average error is 7.5 degrees. This error may easily be attributed to errors in chemical analyses, in pyrometric measurements, to both, or to the inaccuracy of the equation from which the temperatures were calculated.

7. The temperature of the slag can be calculated from the same variables with a maximum variation of 50 degrees and with an average error of 19.5 degrees.

To the extent that the furnace operator is satisfied with the production of metal that meets the silicon and sulphur specifications, the pyrometer has little to offer. Knowing the temperature of the slag and of the metal it is possible to predict the analysis of the following cast. Knowing the analysis of the metal and of the slag, it is possible to estimate the temperature of the preceding cast. The pyrometer has something to tell about what is going to happen and that perhaps is an advantage. Often a few hours mean much in the operation of a furnace. Nevertheless it is easily possible to overrate this advantage.

There is more to the operation of the blast furnace, however, than controlling the silicon and sulphur content of the metal. The real furnace problem is the production of a given tonnage of metal in the shortest possible time and with the least expenditure of materials. The preceding discussion has not touched that problem. The existence of certain temperatures in the hearth has been shown and their effect has been discussed. A complete pyrometric study of the blast furnace should go further than this, it should attempt to find out the reason for the temperatures observed. Every furnaceman is trying to keep his coke consumption at a minimum; the mark of that minimum, the sign which says he shall not go further, is a cold hearth. It has been shown that a reduction in coke lowers the silicon in the metal without indicating a drop in temperature. There is a possibility, therefore—the writers insist, however, that it is only a possibility—that some furnacemen have stopped on the high side of the minimum from fear of low-silicon iron. It is where a serious attempt is made for a low-coke campaign that the pyrometer promises to be most useful. Take the case of furnaces 15 and 16 in Table 1, which were burning 1,518 and 1,502 lbs. of carbon per ton of metal. The pyrometer readings show that there was no danger here of a cold hearth. The metal and slag temperatures are above the average, and the tuyere temperatures are, respectively, the highest and the third highest observed.

Manganese in the Blast Furnace.

Manganese oxide, like silica, is reduced at a higher temperature than iron oxide. It is generally believed, therefore, that a blast furnace making high-silicon pig, spiegeleisen, or ferromanganese must operate with a hotter hearth than a furnace making basic iron. The Bureau of Mines has published* a summary of the

*P. H. Royster: Production of Ferromanganese in the Blast Furnace. Bulletin No. 146 (Feb., 1919); Bureau of Mines War Minerals Investigation Series No. 5 (Dec., 1918).

P. H. Royster: Production of Spiegeleisen in the Blast Furnace. Bureau of Mines War Minerals Investigation Series No. 6 (Dec., 1918).

temperatures observed in the hearth of seven ferromanganese furnaces and five spiegeleisen furnaces. The following figures will show how the temperatures in the manganese-alloy furnaces compare with the temperatures in the iron furnaces discussed above.

Furnace	Tuyere Temp., Average, Degrees C.	Slag Temp., Average, Degrees C.	Metal Temp., Average, Degrees C.
Iron	1706	1498	1455
Spiegeleisen	1597	1427	1392
Ferromanganese	1550	1426	1386

The manganese-alloy furnaces are considerably colder than the iron furnaces in spite of the higher temperature required to reduce manganese oxide and in spite of the fact that the average carbon per ton of metal consumed is 5,323 lbs. (2414 kg.) for the ferromanganese furnace and 3,444 lbs. (1,562 kg.) for the spiegeleisen furnace.

It was concluded as a result of the bureau's investigation of manganese furnaces that an improvement in practice would result from the use of less coke and from increasing the ratio of bases to silica in the slag. As an illustration of the use of the pyrometer in furnace control, the following figures may be of interest. The writers observed the operation of a furnace making ferromanganese for 12 days. Certain of the daily operating quantities are shown in Table 7. The charging of this furnace was done on the basis of the silicon in the metal and of the operator's judgment of the hearth temperature. The ratio of bases to silica was quite irregular, but in general much too low. It was only on the fourth and twelfth days that it was anything near what it should have

Table 7—Daily Results of Furnace Making Ferromanganese.

Day	Pounds of Coke per Ton of Metal	Ratio Bases/Silica in Slag	Silicon in Metal, Per Cent	Temp. of Metal, Deg. C.	Temp. of Tuyeres, Deg. C.	Per Cent Mang. in Slag
1	7,718	1.34	2.20	1,412	1,571	11.0
2	8,826	1.36	2.30	1,426	.....	7.8
3	7,974	1.38	2.05	1,450	1,611	6.1
4	8,109	1.52	1.58	1,475	1,622	4.9
5	8,333	1.45	0.61	1,456	.....	9.3
6	8,154	1.48	0.77	1,456	1,598	6.3
7	7,885	1.48	1.78	1,460	1,614	6.1
8	8,534	1.45	0.40	1,514	.....	8.8
9	10,326	1.42	0.41	.....	.....	9.9
10	8,669	1.33	0.40	1,480	1,546	8.5
11	8,579	1.40	0.93	1,480	1,633	6.6
12	6,797	1.52	1.85	.....	.....	4.9

been. On these two days the "basicity" was 1.52, and the manganese in the slag was 4.9. The coke consumption was in every case much too high, its effect being to increase the slag volume, lower the basicity, and increase the manganese lost in the slag. The coke consumption on the twelfth day was but 82 per cent of the coke used on the fourth day, but the results were much better, the per cent manganese in the slag being equally low and the slag volume lower. The failure of the silicon thermometric theorem to give the true temperatures or to serve practically as a guide to good operation is evident throughout. Bearing in mind that the average metal temperature in ferromanganese practice is 1,386 degrees, it will be seen

that this was a very hot furnace. On the eighth day, the metal was extremely hot (1,514 degrees C.) and yet the silicon had dropped over night from 1.78 per cent to 0.40 per cent. The operator, fearing a cold hearth, put on extra coke that day, which took about 24 hours to pass down the stack, running up the coke consumption on the ninth day to the remarkable figure 10,326 lbs. per ton but did not raise the silicon. The tons of metal made on the ninth day was only 38 compared with 47 on the eighth day and an average of about 50 tons per day for the first seven days. It can be shown that it cost the furnace profits about \$3,000 on the ninth day to conclude that the furnace was getting cold because the silicon dropped from 1.78 per cent to 0.40 per cent.

Measurement of Temperatures at the Blast Furnace.

The pyrometric measurements upon which the figures in this paper are based comprise over 3,600 readings at iron furnaces and about 4,100 readings at manganese furnaces. The instruments used were Morse type optical pyrometers, the outfit consisting of two telescopes and absorption screens, four lamps, and three Weston milliammeters. The lamps and one of the absorption screens were calibrated by Leeds & Northrup. The milliammeters were calibrated at intervals during the investigation in the bureau's laboratories against a standard resistance and a standard cell. Effort was made to avoid instrumental errors by frequent interchanging of the four variable combinations; observer, lamp, screen, and milliammeter. There were 48 of such combinations possible and the concordance was satisfactory at all times, except in the case of the Weston ammeter. One of them suddenly began reading 110 degrees C. high, and it was necessary to attach a shunt to it. All of them persist in collecting particles of iron, or magnetic iron oxide, on the magnets obstructing the movement of the swinging coils.

The measurement of the metal temperature is the simplest of the three measurements the writers have attempted. The telescope can be sighted from a distance of about 10 feet (3 m.) on the metal stream flowing over the dam just below the skimmer. Occasionally the presence of traces of slag carried along with the metal causes trouble. Following Burgess, the emissivity of iron has been taken to be 0.40.

The measurement of the slag temperature is somewhat more difficult. The viscosity of the slags observed varied from 3 to 20 C. G. S. and the arrangement of the slag runner is different at each furnace, although in general all of them are difficult to observe. Considerable "spitting" at the cinder notch, clouds of sulphur-bearing gases arising from the stream, the presence of small pieces of chilled slag on the surface of the flowing cinder combine often to tax one's ingenuity to get a fair sight on the slag. The emissivity of the slag has been taken to be 0.65 although it seems probable that 0.70 is more nearly correct. This change in assumed emissivity would necessitate subtracting 10 degrees C. from the slag temperatures as recorded in Table 1.

Forging Temperatures and Rate of Heating and Cooling of Large Ingots

Results of Tests Show That an Optical Pyrometer Can Be Used to Determine When an Ingot Is Ready to Forge. Data Offers Suggestions for Proper Heating.

By F. E. BASH.

In recent years, there have been a number of experiments conducted to determine the rates of heating and cooling of various sizes and shapes of steel ingots. Up to date, however, most of the published data has dealt with small sized ingots, the largest being an 18-inch (46 cm.) cube, the data on which was presented before the Iron and Steel Institute in May, 1918, by E. F. Law. It is due to this lack of information on the rate at which large ingots absorb heat and come to temperature that the heating practice varies so widely in different plants. One of the questions over which there is much debate is the proper rate of heating of large ingots for forging and the time actually required for the center of a mass of steel to come to forging temperature.

As a continuation of experiments described by M. E. Leeds* and at the request of G. R. Norton of the Sizer Forge Company and R. C. Drinker of the Emergency Fleet Corporation, the test described in this paper was carried out on a 24-inch (61 cm.) round ingot and the rate of heating and cooling determined under regular production conditions. The ingot had been partly forged at one end but, on developing a flaw, had been scrapped so that it was available for test. The size and shape of the ingot and its position in the furnace are shown in Fig. 1.

Experimental Ingot.

The ingot was prepared as follows: The end of the 24-inch section that was the top end when it was cast was sawed off in order to remove the part in which there was segregation, as it was not possible to drill this end because of its hardness. Seven holes $\frac{3}{4}$ inch (1.9 cm.) in diameter and 18 in. (46 cm.) deep were then drilled in the end of the ingot, as shown in the drawing, Fig. 1, one hole $\frac{1}{2}$ inch (1.27 cm.) from the top surface, one $\frac{1}{2}$ inch from the bottom, one in the center, and two evenly spaced between the center and the top and the center and the bottom. The holes were drilled 18 inches deep in order to have them farther from the end than the radial distance from the center in order to lessen the effect due to the heat penetrating from the end.

To take temperatures along the length of the surface of the ingot, a 2-inch (5 cm.) iron conduit pipe pipe was half flattened under a press, and the end

pinched shut and welded tight. The pipe was then spot welded to the ingot directly above the line of holes in the end, as shown, thus making it possible to push thermocouples of different lengths down the pipe so as to take temperatures as near as possible to the surface of the ingot. As a check on the gas temperatures near the ingot, two nichrome targets 2x2x $\frac{1}{32}$ inches were welded to $\frac{1}{2}$ -inch iron rods 4 feet long and spotted to the ingot in the positions shown.

Furnace.

The furnace was of the two-door type and had a vertical slot 4 inches (10 cm.) wide and 30 inches (76 cm.) long in the back directly opposite the experimental ingot, through which slot the thermocouples could be pushed into the ingot. On both sides of the slot and 21 inches (53 cm.) from its center were mudded in two usalite porcelain protecting tubes for platinum-platinum-rhodium thermocouples, which were to record gas temperatures. One-inch steel rods, with nichrome targets 2 inches square and $\frac{1}{32}$ inch thick welded on the end, were suspended from the roof of the furnace, one directly over the experimental ingot and two feet above it, one over the production ingot, and one opposite the center of the flue. Peep holes were arranged in the walls opposite these targets so that optical pyrometer readings could be made at intervals as a check on gas temperatures.

In order to calculate the heat losses from the furnace, mercury thermometers were suspended around the outside of the walls at intervals and the bulbs packed against the brick with asbestos wool. To take the temperature of the outside of the roof, a thermocouple of No. 16 B. & S. gauge iron and constantan was prepared and the hot junction buried in the layer of dust on the top of the furnace.

Thermocouples and Apparatus.

To take the ingot temperatures, thermocouples were prepared as follows: A length of No. 14 B. & S. gauge chromel wire was welded to an iron plug $\frac{3}{8}$ inch (9.5 mm.) in diameter and approximately 1 inch (2.5 cm.) long. The wire was then threaded through porcelain insulators and drawn through a length of $\frac{5}{8}$ inch (1.5 cm.) seamless steel tubing. $\frac{3}{8}$ inch inside diameter, until the plug was flush with the end of the tube. The steel tube and plug were then welded over smooth. The leads from the cold ends of the thermocouples to the Leeds & Northrup potentiometer recorder were of No. 16 constantan and chromel, bringing the cold junction to the recorder. A calibra-

*Some Neglected Phenomena in Heat Treatment of Steel. Proc. Am. Soc. Test. Mat. (1915) 15.

From paper read before September, 1919, meeting of A. I. M. and M. E., Chicago.

the end of the production ingot with the ash on and 2,061 degrees F. (1,128 degrees C.) on the surface after the ash was scraped off. This fact may cause a heater to overestimate the temperature. When the ingot was charged this fine ash had settled all over the iron rods suspended from the roof and made them appear 1/2 inch larger in diameter than they really were; also the two nichrome targets suspended over the ingots had burned off while the target at the entrance to the flue was partly burned. Readings with the optical pyrometer made on the suspension rods on the side in the shadow from the flame, with the ash clinging to them and with the ash scraped off, agreed to 5 degrees F. (2.7 degrees C.). Readings on the side toward the flame were considerably higher due to reflections.

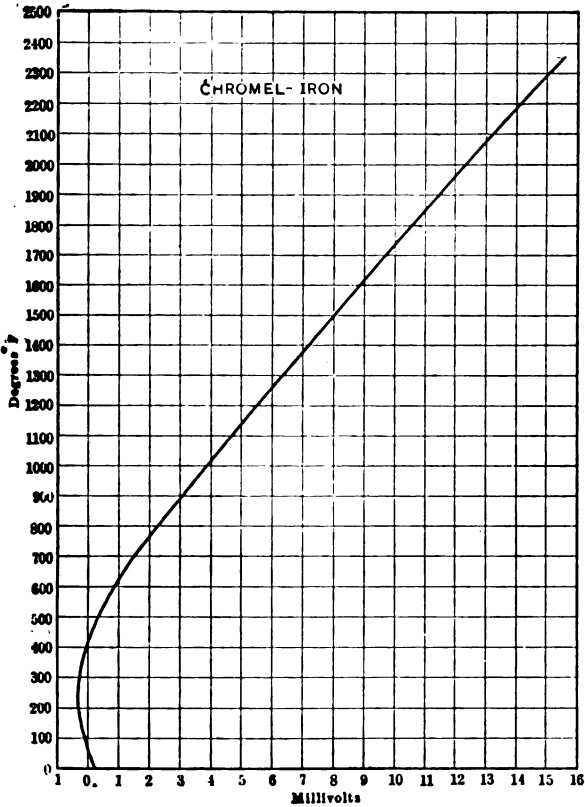


Fig. 2—Chromel-Iron Thermocouple Calibration.

The flame was a pulsating one and reached beyond the experimental ingot so that, on making a reading with the optical pyrometer, the filament appeared alternately light and dark. The readings taken, which appear in the log, show the effect of the flame on the temperature read; this flame effect amounted to from 12 degrees to 22 degrees F. (6.6 degrees to 12.2 degrees C.). A balance was made with the optical pyrometer on one of the rods through the fine ash haze in the furnace and then the coal and air were cut off and another reading made directly afterward; this agreed exactly with the first reading. For that reason we can say that there is no noticeable error due to the ash when making a reading through it with the optical pyrometer. The log of the test and data taken in addition to the ingot temperatures are given in the following tables.

According to the curve shown in Fig. 1, after seven hours heating the ingot had reached a temperature of 2,370 degrees F. (1,299 degrees C.) at the surface and 2,287 degrees F. (1,253 degrees C.) at the center; this was considered a good forging temperature. The cooling curve shows that if forging were started 15 minutes after the ingot was pulled from the furnace the outside temperature would be 2,125 degrees F. (1,163 degrees C.) and the center would be 2,280 degrees F. (1,249 degrees C.); the temperature 5 inches (12.7 cm.) from the surface would be 2,260 degrees F. (1,238 degrees C.). As the outside temperature drops so rapidly and the center so slowly, there can be a temperature difference of 150 degrees F. (83 degrees C.) between the two in the furnace and by the time it is ready to forge or shortly after starting, the center will be the hottest part of the ingot.

Table 1—Log of Test.

Time	Temp.	Remarks
A. M.	Degrees F.	
8:45	2070	O. P.* Reading in porcelain tube, gas temperature.
10:30		Charged experimental ingot.
11:00		Charged production ingot (3 ft.), not bricked up.
11:15	1845	O. P. on N ¹ , dark.
11:15	1857	O. P. on N ¹ , bright; flame effect, 12° F.
11:25	1881	O. P. on M, (rod), dark.
11:25	1903	O. P. on M, (rod), bright; flame effect, 22° F.
P. M.		
12:30		Changed coal feed to 54 rpm.
		Changed gate opening to 2 3/4 in.
	2044	O. P. on N ¹ , light.
	2020	O. P. on N ¹ , dark.
	2005	O. P. on M, dark.
12:45		Pushed production ingot clear in, and bricked up.
1:05		Changed coal to 69 rpm.
		Changed air to 3 1/4 in.
1:50		Coal and air off for 2 minutes.
1:57	2191	O. P. on N just before power off.
1:58		Power off.
2:01		Power on.
2:02	2080	O. P. on N just after power on.
3:06		Power off.
3:08		Power on.
3:50	2202	O. P. on loose ash on end of production ingot
3:51	2061	O. P. on end production ingot, clean.
4:03		Coal to 56 rpm, air to 2 3/4 in.
4:22		Coal to 47 rpm, air to 2 3/8 in.
5:30		Water flowing through door 10 1/2 lb. in 20 sec., heated from 25° to 55° C.
6:05		Ingot taken out.

*Optical pyrometer.

The heating curves of the ingot from the room temperature to, approximately, 950 degrees F. (510 degrees C.) are estimated and dotted in. In the case of couples No. 1 and 7 it is possible that the temperature came up more rapidly than shown. The time after charging the ingot to the beginning of the record was taken up in inserting the couples and bricking up the slot through which they were inserted.

The platinum platinum-rhodium thermocouples with the usalite protecting tubes registered gas temperatures very accurately and did not seem to be affected by the proximity of the ingot. This is shown by the readings with the optical pyrometer on the suspended targets. The heating curves show that optical readings on the target above the experimental ingot show gas temperatures about 20 degrees F. higher than that recorded by the thermocouple at the side of the ingot next to the flame, and that readings on the

Table 2—Optical Pyrometer Readings, in Degrees F.

Time, Hours	Target Center Flue J	End Center Prod. Ingot Q	Over Target Prod. Ingot K	Over Target Exp. Ingot M	on Exp. Target Ingot Front N ¹	Target on Exp. Ingot Back N	Back Wall by Couple No. 12 O	Back Wall by Couple No. 13 P	End Wall near Flue R	Back Wall Center S	Floor Combustion Chamber T
3:17	1993	1773	2120	2229	.....	2191	.....	.....	.....	.....	.....
4:17	2075	1965	2209	2328	2305	2305	2277	2241	2124	2196	2343
5:34	2107	2061	2233	2378	.....	.....	2449	2385	2178	2325	2473
6:34	2140	2164	2265	2350	.....	.....	2346	2309	2174	2265	2370

Table 3—Outside Brick Temperatures, in Degrees F.

Time, Hours from Start	Between Doors A	End Wall C	Back Wall Combustion Chamber D	Back Wall near End F	Top Over Combustion Chamber G	Top over Exp. Ingot H	Top over Prod. Ingot S
2:50	211	222	192	177	.....	.....	.....
3:00	.....	.....	.....	.....	360	.....	.....
3:17	.....	.....	.....	.....	.....	379	.....
3:50	234	236	204	190	.....	.....	.....
4:17	.....	.....	.....	.....	.....	366	350
4:50	244	246	213	196	.....	.....	.....
5:34	.....	.....	.....	.....	.....	360	.....
5:50	257	255	220	206	.....	.....	.....
6:34	.....	.....	.....	.....	.....	373	.....
6:75	270	265	220	212	.....	.....	.....

Table 4—Outside Ingot Temperatures, in Degrees F.

Time, Hours from Start	Top Exp. Ingot 1 Ft. from Door U	Top Exp. Ingot 2 Ft. from Door V	Top Exp. Ingot 3 Ft. from Door W	Top Prod. Ingot 1 Ft. from Door X	Top Prod. Ingot 2 Ft. from Door Y	Top Prod. Ingot 3 Ft. from Door Z
3:53	249	157	123	.....	.....	.....
5:50	.....	.....	.....	227	143	117
6:25	338	191	142	.....	.....	.....

Coal Record.

	Pounds
10:30-12:30: 39 rpm = 9.7 lb. per min., 120 min. at 9.7 lb. per min.	= 1,164
12:30-1:05: 54 rpm = 14.4 lb. per min., 35 min. at 14.4 lb. per min.	= 504
1:05-4:03: 69 rpm. = 21.53 lb. per min., 178 min. (shutdowns at 1:58-2:11 and 3:06-3:08, 15 min.), 163 min. at 21.53 lb. per min.	= 3,509.39
4:03-4:22: 56 rpm = 15.1 lb. per min., 19 min. at 15.1 lb. per min.	= 286.9
4:22-6:05: 47 rpm. = 12.1 lb. per min., 103 min. at 12.1 lb. per min.	= 1,246.3
Total coal	6,710.59

target spotted to the ingot are about 20 degrees F. lower than the thermocouple. This is good proof that the thermocouple indicates the gas temperature as it is the mean of the two. Optical pyrometer readings on the target suspended over the 26 inch production ingot check very closely with the temperatures recorded by the platinum thermocouple at the side of the experimental ingot away from the flame, which is reasonable to believe. Optical readings made on the top of the experimental ingot near the end of couple No. 9 check very closely to the temperature recorded by the couple; this indicates that the optical pyrometer reads the true surface temperature of the ingot.

Two optical readings made on the front wall after the rod suspended from the roof had burned out do not show any relation to the ingot temperature, but readings made on the back wall between the two

ingots and near couple No. 13 check the couple readings fairly closely, the greatest difference being 20 degrees F. Readings on the back wall, on the flame side of the experimental ingot, agree with the gas temperature as shown by thermocouple No. 12 to 40 degrees F. It would seem from this that a reading with the optical pyrometer on the back wall at the height of the ingot from the floor will give the gas temperature at that point to within 30 degrees to 40 degrees F.

With the exception of the time at which the ingot was going through the critical period, the temperatures along the surface of the ingot always fell between the temperatures of the gases on both sides. The point nearest the door, naturally, was the coolest, the points about the middle of the furnace were the hottest, and the point nearest the back wall was somewhat cooler than the center of the furnace. The drop in the temperature of the gases from one side of the ingot to the other averages about 125 degrees F.; this represents the heat lost by the gas and absorbed by the ingot. The temperature drop of the gas from the combustion chamber to the flue averaged from 230 degrees to 266 degrees F.; the heat in the flue gases was used to evaporate water in waste heat boilers and so was conserved. The temperature gradient along the ingot from the portion just outside the door to the inside is very great, as is shown in Table 4. The stresses set up at this section must be very large and injurious.

The coal used amounted to 6,710 lbs. (3,043 kg.). This was calculated from the revolutions of the screw feed which had previously been calibrated. Taking the weight of the experimental ingot heated as 13,083 lbs. (5,934 kg.) and the production ingot as 18,050 lbs. (8,187 kg.), which we will estimate was 0.8 heated, the total weight of steel this amount of coal will heat when fired in this manner would be 27,533 lbs. (1,262 kg.), or the rate of using coal will be 0.244 lbs. (0.110 kg.) of coal per pound of steel. The rate was really less than this as the ingot was hot in 6½ hours and the coal is calculated to 7½ hours. To heat a 24-inch (61-cm.) ingot in 7 hours, in this type and size of furnace with this kind of fuel, means that the coal should be fired at the rate of 16 lbs. (7.25 kg.) per min. To bring it to temperature in a longer time, the coal must be fed more slowly and more coal will be needed; how much more will depend on the radiation losses. The heating value of the coal used was 13,000 Btu per lb. so that the heat developed was 87,230,000 Btu. The heat absorbed by the steel was approximately 7,270,000 Btu., the percentage of the total heat absorbed by the steel being 8.32 per cent.

When the ingot was pulled from the furnace and laid on the ground, four couples were replaced in the

ingot and the cooling curve taken. The center of the ingot showed the passage through the critical point more markedly than any other point, as was also the case in heating. The recalescence and decalescence points were at practically the same temperature. After the ingot had cooled to 750 degrees F. (399 degrees C.) all the points in it from 1/2 in. (1.27 cm.) under the surface to the center cooled together and were all at the same temperature as they cooled.

Forging Temperatures.

In Table 5 are given the temperatures read on three four-door furnaces at the Sizer Forge Company, with the Leeds & Northrup optical pyrometer. The furnaces were lettered J, K, and L, and were so arranged that the flames were from left to right on L, right to left on K, and left to right on J. J had a bridge-wall in the combustion chamber, but K and L had none. The doors were numbered consecutively, beginning with the one next to the burner.

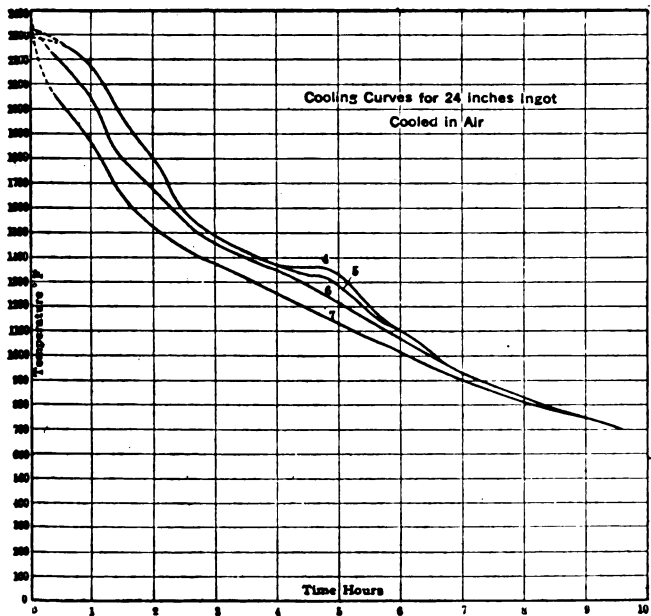


Fig. 3—Cooling Curves.

Table 5—Temperatures on Forging Furnaces.

Time	Temperature, Degrees F.	Remarks
11:55	1525	Finished forging 26 in. ingot to 13 in., surface reading.
12:08	2477	On surface No. 1 K, roll ingot.
12:10	2511	Back wall right of ingot No. 1 K, flame right to left.
12:11	2350	Back wall left of ingot No. 2 K, flame right to left.
12:12	2221	Back wall right of ingot No. 3 K, flame right to left.
12:12		Pull ingot from No. 2 L.
12:13	2169	Back wall right of ingot No. 4 K.
12:14		Charge above ingot in No. 1 L.
12:17	2245	Back wall No. 2 L, door open from 12:12.
12:19		Charge cold ingot in No. 2 L.
12:22		Coal off of K furnace, air about 1 1/2 in. opening.
12:35		Bricking up Nos. 1 and 2 L, coal off and air on.
12:32	2505	Floor of combustion chamber of K furnace, coal on.
12:34	2508	Wall of combustion chamber of K.
12:36	2529	Right of No. 1 K, wall; flame right to left.
12:36	2392	Left of No. 1 K, wall; flame right to left.
12:37	2392	Right of No. 2 K, wall; flame right to left.

12:38	2346	Left of No. 2 K, wall; flame right to left.
	2346	Right of No. 3 K, wall; flame right to left.
12:39	2289	Left of No. 3 K, wall; flame right to left.
	2289	Right of No. 4 K, wall; flame right to left.
	2265	Left of No. 4 K, wall; flame right to left.
1:09	2403	Ready to pull 26 in. ingot in No. 1 K.
1:10	2580	Right No. 1 K, wall.
	2343	Scale on ingot 30 sec. after being drawn from furnace.
	2111	Scale in groove under press.
1:12	2140	Clean spot.
1:16	2015	Clean spot.
1:19	1851	Groove.
1:20	1919	Second groove, clean.
1:22	1886	Third groove, clean.
1:24	1990	Deep groove under cutter, clean; approximately 6 in. deep.
1:26	2015	Deep groove under cutter, clean; approximately 6 in. deep.
1:32	1930	Groove, light scale.
1:41	1685	Small groove.
1:44	1706	Deep groove.
1:50	1741	Deep groove near end.
1:50	1767	Deep groove third from end.
1:56	1663	Corner.
2:00	1373	Outside 24 in. section.
	1576	Corner.
2:08	1315	Finish 24 in. section.
	1576	Finish 13 1/2 in.
2:14	1407	Finish 24 in.
	1407	Finish 13 1/2 in.
2:22		Stop working.
1:58	2460	Right No. 2 K, No. 1 empty, flame right to left.
2:03	2423	Left of No. 2 K., flame right to left.
2:26	2385	Left of No. 1 L; flame left to right.
	2285	Right of No. 1 L.
	2233	Right of No. 2 L.
		No. 3 empty.
	2233	Left of No. 4 L.
2:30	2221	Right of No. 4 L.
2:32	2442	Combustion chamber of K.
		J Furnace
3:56	2403	Bridge-wall; flame left to right.
	2321	No. 2 J left.
	2249	No. 2 J right.
	2124	No. 3 J right.
		No. 1 J and No. 4 J empty.
	2148	No. 4 J, back wall.
		L Furnace
4:00	1863	Left of No. 4 L, flame left to right.
	1913	Right of No. 4 L.
	2039	Right of No. 3 L.
	2148	Right of No. 2 L.
	2128	Right of No. 1 L.
4:05	2221	Combustion chamber, wall.

The drop in temperature from one end to the other of the four-door furnaces on which readings were taken range from 164 degrees to 308 degrees F., depending on the length of time the ingots have been in, how fast the coal is being fired, and the type of furnace.

Conclusions.

It is possible to heat a 24-inch ingot from room temperature to forging temperature in seven hours but the question is raised whether this fast rate is not injurious to the steel, especially while the steel is still comparatively cold, large stresses being set up which may cause internal fissures. The rate at which an ingot can be heated without injury depends on the kind of steel, chrome steel being very tender while low-carbon steel will stand more abuse. Opinions differ on the length of time necessary to bring this size of ingot to temperature, but the best practice appears to indicate slower heating up to the critical

(Continued on page 573)



Power Piping Requirements in Modern Mills

Development of Power Generating Machinery Has Stimulated Progress in the Manufacture and Mode of Installation of Power Piping and Placed Heavier Demands on Specialists.

By J. ROY TANNER and GEORGE J. STUART.

The development of power generating machinery has compelled and stimulated a corresponding progress in power piping. Pressures have doubled and tripled. Sizes required, especially for low pressure, condenser and water piping have increased many fold. Superheated steam meant new designs and new materials. As a result, the pipefitter of our recollection, with his small shop, a few tools, and a cutting and threading machine or two, has been transformed into a manufacturer with all of the foundries—iron, steel, and brass—pattern shop, machine shops, and pipe shops full of special machinery, and engineering and construction organizations of trained specialists.

Not much more than a decade ago the largest single contract for piping amounted to around \$100,000. Today plants with \$500,000 worth of piping placed in a single contract are not uncommon and \$1,000,000 jobs are not unknown.

Pressures.

The steam pressures carried have gradually increased until the present "extra heavy" material used for high-pressure steam is designed for 250 pounds working pressure. The tendency on the large installation is still upward. Material designed for 350 pounds and superheat is in use with success, but has not yet had wide enough application to be reduced to standard practice.

Superheat.

The steam-turbine has changed practice by bringing superheated steam from occasional into extensive use. It developed, shortly after the introduction of superheat, that some of the materials in use for saturated steam would not stand the higher temperatures and it was necessary to find substitutes for cast iron and bronze. The former was replaced by cast steel, and the latter to a great extent by nickel alloys—notably "Monel metal," with substantially the same thermal expansion as steel.

From paper read before Engineers Society of Western Pennsylvania.

At first, there were very great difficulties in obtaining steel castings suitable for valves and fittings and, in order to be assured of castings sound at the joint of juncture between the heavier flange section and the lighter shell section, many engineers drew their specifications calling for a finish strip in each opening of cast steel fittings, to a depth of about twice the flange thickness. This had to be machined out to the bore dimension of the fitting, thus uncovering any defects which might exist.

Foundry practice improved, however, and it soon became possible to make or obtain pipe castings with reasonable certainty of soundness.

The evolution of steam and mountings to withstand this service was also satisfactory. Some early installations, after failures of bronze, went back to first principles and used stems of steel with no seat or disk mountings. Nickel steel was tried but this meant forgings. Nickel was also used. The discovery and development of "Monel metal" has given us a material known to be safe for use with steam pressure up to 250 pounds and the superheating used at this pressure.

The effect of superheated steam upon materials for piping will be touched upon later.

Standardization.

The importance of standardization as a factor in the industrial position of this country today is nowhere better illustrated than in this industry under discussion. A few years ago each manufacturer had his own standard for the dimensions of flanges, fittings, and drilling templates. This compelled the large users of piping, such as steel mills, to adopt something which was very likely to be original. Also, about the first thing an engineer did after putting up his sign, was to calculate and design his own piping standard. There was a tremendous amount of brain power consumed which can now be diverted to other purposes. The effect of this confusion was that manufacturing in all that the word implies was impossible because changes of flange sizes or center to face had to be made at frequent intervals. This condition prevailed long after the Ameri-

can Society of Mechanical Engineers in 1894 adopted, after conferring with the Master Steam and Hot Water Fitters and some of the manufacturers, a standard flange templet which subsequently became the "A. S. M. E. Standard" used for lower pressures, along with the "Manufacturers' Standard" for extra heavy material, in 1901, and it was several years after this before the flange situation became clarified.

Some time after 1910 a group of manufacturers of valves and fittings formed an organization called the "Committee of Manufacturers on Standardization of Valves and Fittings," and began the work of designing a completely standardized line of fittings, including center to face, and shell thickness. This work was completed and published and about a year later revised to meet the views of the American Society of Mechanical Engineers regarding the bolting of extra heavy flanges larger than 12-inch. This revision was accepted at a conference in Washington by representatives of the United States government, the American Society of Mechanical Engineers, the Master Steam and Hot Water Fitters, and the manufacturers' committee. The American Society of Mechanical Engineers adopted the report of its committee—compiled under the direction of the late H. G. Stott—and thus made effective the "American Standard for Pipe Flanges, Fittings and their Bolt-ing," to become effective January 1, 1914. The report of this committee was a masterpiece of complete analysis.

The American standard consisted of specifications for "standard" material up to 125 pounds pressure and "extra heavy" material up to 250 pounds pressure.

The American Society of Mechanical Engineers and the manufacturers subsequently collaborated in standardizing hydraulic flanges up to 3,000 pounds pressure, culminating in the adoption of a report in December, 1918.

Economy demanded the use of a lighter design than that specified for 125 pounds, for use on low pressure water, condenser service, etc., and the American Society of Mechanical Engineers has made a recommendation for lighter shells and smaller bolts than the American 125-pound standard, and flanges of the same diameter, thickness, and bolt spacing. The manufacturers' committee, however, is considering the advisability of using a thinner flange for this service, owing to the foundry difficulties attending such a great change in section, and may request the American Society of Mechanical Engineers to reconsider this point.

Some work had been done by the manufacturers' committee to determine the feasibility of standardizing valve dimensions from center to face, but with no results. In the fall of 1918, when the Emergency Fleet Corporation was struggling with the problem of a design for the piping of fabricated ships, the standardizing engineer for the Emergency Fleet Corporation—John A. Stevens—who played a large part in formulating the boiler code of American Society of Mechanical Engineers, attacked the problem of interchangeable dimensions for the valves to be used by the fleet, calling to Philadelphia engineering representatives of all the large valve manufacturers and,

had it not been for the armistice, the fleet would probably by now have had a standard center to face dimension for every valve to be used by them on shipboard. It is, therefore, not impossible that at some future date, we may even have interchangeable face to face dimensions of valves.

A large amount of standardization work has been done by the Power Piping Society, an organization of fabricators and erectors. The "Standard Specifications for Power Piping" adopted by the society in 1915 was the result of the experiences of a group of men who had installed a considerable part of the power piping in this country, and can therefore be accepted as safe modern practice.

Thus out of chaos has come some degree of order, for the benefit of the user of pipe, valves, and fittings.

Effect of Superheated Steam.

In general all of the materials except steel, wrought-iron, and "Monel metal," have proven unsuitable for superheated steam. Superheat had not long been applied to steam for power purposes until failures began to appear and the reasons therefor are believed to be apparent in view of the following facts. For the figures given for the behavior of the various metals under tensile stress we are indebted to the Crane Company which published in the "Valve World," in January, 1913, the results of an exhaustive series of tests to determine the properties of metals and alloys under high temperatures. Wrought steel and wrought-iron have given satisfactory service under superheat conditions. No figures are available for their behavior at high temperatures but it is safe to assume that they are similar in this respect to cast-steel.

Cold rolled steel is of interest because of its use for valve-stems. Samples tested cold and showing a tensile strength averaging 82,800 with 76,000 elastic limit remained with practically constant characteristics up to 525 degrees F. At 600 degrees, tensile strength was still high but the elastic limit dropped to 54,275. Both properties fell off rapidly at higher temperatures.

Rolled bronze of 54,450 and 45,000 tensile strength and elastic limit, respectively, drops off rapidly from the start, and at 600 degrees the corresponding figures are down to 35,050 and 23,735 for the tensile strength and elastic limit, respectively. These figures point to the unsuitability of this material for superheat, in addition to difficulties from the greater coefficient of expansion.

Gray iron of 22,000 pounds tensile strength remains practically unchanged up to 1,000 degrees, and semi-steel up to nearly 900 degrees so were it not for another property of both of these metals they would be almost ideal. The trouble lies in the extremely low elastic limit and the fact that permanent set begins at low stress, together with expansion and contraction when the metal is alternately heated and cooled. As each contraction is slightly less than the preceding expansion, in course of time there is an appreciable growth in all dimensions and a weakening of the material. Growths as great as one-fourth inch to the foot are not uncommon. This is fatal to valves, as the seats become so loose that they fairly drop out.

Up to 500 degrees F. cast iron and semi-steel seem to behave satisfactorily if temperatures are constant, but the uncertainty of constant temperatures where superheaters are installed has led the writers to conclude that the only safe practice is to eliminate cast iron and semi-steel in any installation where the steam passes through a superheater. It is true that valves of semi-steel with "Monel metal" mountings have worked successfully at temperatures above 500 degrees but the writers know of no such case where the operation was not continuous and the load practically constant. On the other hand, there are installations where lower temperatures with great fluctuation caused the same material to fail absolutely.

Cast bronze of 33,735 tensile strength and 25,035 elastic limit, behaves well up to 450 degrees, but at 600 degrees the figures drop to 23,150 tensile strength and 17,160 elastic limit, so that it is the safer proceeding to eliminate it under superheat.

Cast steel of 73,325 pounds and 39,817 pounds tensile strength and elastic limit, respectively, holds up to 600 degrees at 67,366 pounds and 29,422 pounds tensile strength and elastic limit, respectively. At 720 degrees these properties become 58,713 pounds and 33,313 pounds tensile strength and elastic limit, re-

spectively. At 750 degrees they are 41,388 pounds and 27,223 pounds tensile strength and elastic limit respectively. It is thus apparent that cast steel is the metal best adapted to use with superheated steam, but with some of the higher temperatures now discussed, on account of the reduction in strength, very careful design will be required.

Cast "Monel metal" of 52,870 pounds and 30,088 pounds tensile strength and elastic limit, respectively, at 450 degrees changes to 47,200 pounds and 22,350 pounds tensile strength and elastic limit, respectively, and at 700 degrees to 41,787 pounds and 21,700 pounds tensile strength and elastic limit, respectively. This behavior approximately parallels that of cast steel and renders the combined use of these metals very satisfactory. To the knowledge of the writers, there has been no trouble encountered with temperatures below 600 degrees but above that point some difficulty, mainly mechanical, has occurred, though up to the present time there is no certainty that the use of "Monel metal" was blamable.

Rolled "Monel metal" of 104,900 pounds tensile strength and 78,350 pounds elastic limit, at 600 degrees, changes to 89,600 pounds and 57,950 pounds; and, at 750 degrees, to 67,600 pounds and 42,550 pounds.

Economical Operation of Mill Boilers

Analysis of Heat Losses in the Boiler and Stack—Preparation of Coal—Training of Operating Crews Important—Forced Blast for Bituminous Coal Recommended.

By W. E. SNYDER.

During the past two years a great deal has appeared in the technical press, and in papers before engineering societies on the subject of fuel economy. The intention of the writers is good and much of the discussion is usually too academic and fails to get at the real heart of the matter, by failing to give proper importance to the training of the operating men of the plant. The assumption seems to be that the superintendent of the works has the power to create to order an operating crew for the boiler house which will be of high grade intelligence, coupled with an enthusiasm for the work which will only make it necessary to post a series of typewritten rules in a few conspicuous places to insure safety and high efficiency. As a matter of fact, many boiler plants are operated under the charge of boiler house foremen who used to be water tenders, and are still water tenders in their knowledge of the work, with enlarged duties. The water tending is done by men who used to be firemen, and the firemen were formerly ash men or flue blowers, most of whom have been recruited, not very long before, from the ranks of laborers. In their work they have acquired a certain familiarity with the stok-

ers, boilers, pipes, valves, etc., with which they have to deal, but they have practically no knowledge of the methods of operation which it is necessary to follow to save fuel and labor.

There is no use in becoming disgusted with the general lack of intelligence of such a boiler house crew and firing them all out. This would result only in getting together, after much effort, another and different set of men, with about the same general characteristics and abilities. We know how to set boilers properly to use coal efficiently; the problem is to operate the boilers day after day, so that present-day engineering knowledge will be utilized by the men directly in charge.

The operating crews of boiler plants must be trained and the problem is how best to accomplish this training. In order to make some useful suggestions on this point, it is necessary to discuss briefly the losses of fuel or heat which take place when coal is burned under a boiler. The best way to improve efficiency is to reduce the quantity of heat lost. However, in order that the coal may be used efficiently it should go to the boilers properly prepared, and this phase of the subject deserves a little special discussion.

Preparation of Coal—Only the coals used in the Western end of this state are referred to, i.e., those

From paper entitled "The Practical Operation of Industrial Boilers," read before Engineers Society of Western Pennsylvania.

from the Pittsburgh, Upper and Lower Freeport, Upper and Lower Kittanning, and Brookville seams. Under normal operating conditions at the mines, the operators try to produce clean coal, by various systems of fining the miners who load unclean coal, and by having hand pickers on the cars to throw out the biggest chunks of slate as the coal is loaded. If there be any laxity on the part of the consumer, owing to a large demand for coal, the result is an increase of slate and dirt in the coal. Only continued inspection, accompanied by occasional trips of the inspector to the producing mines will keep down to a minimum the incombustible matter which the coal contains.

In general, it does not pay to use the so-called $\frac{3}{4}$ -inch screened coal, which costs more than the straight "run-of-mine." The screen at the mine is usually made of narrow steel bars, placed $\frac{3}{4}$ inch to 1 inch apart and at an angle of about 45 degrees. The openings between the bars soon become clogged up with small pieces of coal, so that the screen is not much more than a chute, and takes out only a part of the slack. Coal for chain-grates and inclined grate stokers ought to be crushed so that the largest lumps will pass through a one-inch ring, and then the fuel burns out uniformly by the time the fire reaches the back end of the grate. The best way to prepare coal for furnaces of this kind, at a plant where there are gas producers, is to pass the "run-of-mine" coal through a coarse crusher, so that the largest lumps are broken down to a size of four or five-inch cubes, then pass the crushed coal over a rotating or shaking screen of about 1 or $1\frac{1}{4}$ inch mesh. In this way the screening is far more effectively done than it is when passed over an inclined bar screen. All the coal that goes through the screen is the kind best adapted to boilers while the coarse coal that goes over the screen is just right for gas-producers, locomotives and miscellaneous hand-fired furnaces.

The coal coming from the different mines of this section does not vary as much in the results which it produces, as the coal from the same mine may vary, due to carelessness in mining. I once made a series of 29 tests, carried out in every detail, as completely as such tests can be made. Each of these tests consisted of five 24-hour periods, each period in itself being a complete test, during which the boiler was run at a different capacity, varying from the rating of the boiler to 60 per cent over rating. Coal from 21 different mines and five different seams of this section was used. The coal was fired by intelligent firemen, on flat grates, under a Stirling boiler of 275 hp. Some of the coal used was the so-called $\frac{3}{4}$ -inch screened; and yet, notwithstanding the difference in the grades and the mines and the seams, the overall efficiency of boiler and grate for the entire series of tests varied only between 59.6 per cent and 63.5 per cent, or a difference of 3.9 per cent. This means that only 6.5 per cent more of the poorest coal would be required than if the best were used—all comparisons being made on a dry coal basis.

Heat Losses After Coal Is Fired—When coal is fired into a furnace, the potential heat which it contains goes to one of four places:

1. Into the boiler.
2. Up the stack.
3. Into the ash-pit.
4. Into the air surrounding the boiler setting and piping.

Only the heat which enters the boiler is useful; that which goes to the three other places is wasted. If these three sources of waste are dealt with separately, it simplifies the subject so that it is more easily comprehended by men without knowledge of theoretical principles.

The heat lost up the stack may vary from 15 to 35 per cent, and the reduction of this loss is the most important step in improving boiler economy. This loss is due to:

- (a) Excess air.
- (b) Sensible heat.
- (c) Incomplete combustion.
- (d) Moisture in coal.

Excess air is the air which is heated from the temperature of the furnace air supply to the stack temperature, and passes through the boiler without the oxygen which it contains combining with the combustible elements of the fuel. It is due to holes in the fire or openings at the back end of chain-grates; thin fires; leakage between the brickwork and the metal parts of the boiler and its setting; open doors, etc. The reduction of this excess air is most necessary in improving economy. The most important work of the fireman in reducing this waste is to keep the grates evenly covered with a fire thick enough to utilize the oxygen in the air coming through, the best condition having been determined by analysis of the flue-gas; also having the furnace doors open as short a time as possible when firing coal or working with the fires.

The leakage of air through any opening in the setting other than those into the furnace proper is an especially bad condition, for the reason that this air has no chance whatever to combine with the combustible elements. It simply acts as a carrier of heat to the stack. There are a variety of compositions on the market, used for coating over the brickwork itself to make it impervious to air, but we have never derived any benefit from their use, though careful comparative tests have been made. It is hardly possible for air to leak through a solid brick wall 18 or 22 inches thick, when the vacuum inside is only slightly below atmospheric pressure. It is entirely practicable to plug permanently the small openings and cracks in the brickwork through which air can pass into the setting. Ill fitting cleaning doors have the same harmful effect as any other openings into the setting, which is not the case with doors opening into the furnace, as a little air over the top of the fire is often a benefit.

The total sensible heat carried away in the products of combustion is due to their temperature above that of the entering air. This waste is increased by the gas passages through the boiler being too direct; by holes in the baffling; dust on tubes and other heating surfaces; dirt and scale inside the boiler; too much forcing, etc.

For the gas passages being too direct, the design is responsible and not the operating men. If it is

not possible to put in additional baffles, it is necessary either to run the boilers as they are or to install economizers, which we have done in one plant of vertical water-tube boilers, with a very substantial return on the investment. Sometimes boilers give very good efficiency when they are new and the baffling in good condition, but after they are used awhile and it becomes necessary to replace tubes, the baffling is partially wrecked in the process and the hot gas short circuits through the broken baffling. In some boilers with cross baffles it is extremely difficult to repair these baffles properly, and this is my main objection to boilers with baffling perpendicular to the tubes. If the tubes become bent or warped in service and have to be driven out, there is more work in repairing the baffles than in replacing the tubes. It may be that the most modern boilers of the cross-baffle type have improved baffling, but I refer here, as in other parts of this discussion, to those of the older design.

The development of mechanical flue blowing equipment is a splendid improvement. I do not think it is ever possible to keep the heating surface of boilers clean by hand blowing, as it is almost an impossibility to reach some parts of the boiler and there is too much opportunity for the men to slight their work.

The use of mechanical flue blowers not only keeps the heating surface cleaner than hand blowing, but it avoids opening the doors of the setting frequently and thus allowing large quantities of air to be drawn in. Also, these doors never fit tightly and the cracks around them have to be repacked every time they are used, which is often done in such a way that there is a continuous leakage of air. Although these beneficial results follow the use of mechanical blowers, I do not mean that all hand cleaning is eliminated. When a boiler is off for cleaning, it ought to be inspected and the heating surface swept or blown off wherever necessary.

Even with the most conscientious work in cleaning the fire side of the heating surface, the tubes often become coated with a thick layer of very fine dust, tarry or sooty deposit, which it is not possible to blow off. This is a splendid insulator, and the worst trouble to deal with that I know of in keeping the boilers perfectly clean. Joseph Harrington, administrative engineer, Chicago district, United States Fuel Department, recently sent out a letter stating that this deposit can be completely cleaned off by the use of common salt. For an ordinary boiler, two or three large shovelfuls of salt are thrown over the top of the fire and the furnace closed up. It is said that this completely cleans the heating surface, and that two years' use had caused no harmful effects whatever. Of course this treatment does not have to be used every day, but only when the condition of the tubes indicates the presence of the deposit mentioned. It is a simple remedy, which is apparently effective and is worth careful trial.

There is not much excuse now for dirt and scale inside of a boiler. When it is necessary to use water that is permanently bad, either due to acid, or suspended or scale forming matter, a water purifying plant is the only solution. However, even with a

water purifying plant, some scale will form in the tubes, but there are thoroughly good turbine tube cleaners now made with which it is possible to clean the tubes completely; the only thing necessary is to be sure the cleaner is the right size for the tube, as, if it is too small, the men will push it through without cutting out all the scale. Before these tube cleaners were developed, I have seen four-inch boiler tubes filled almost solid, and scale 1 to 1½ inches thick was common, but there is no longer any reason for such conditions, if even the most ordinary supervision is exercised. In this connection it is important that the boiler house foreman inspect personally every boiler after it is cleaned. The inside of the tubes of some boilers cannot be examined except by the inspector getting into one drum and an assistant with a light getting into another. This is where the instruction of the boiler house foreman must come in.

The heat loss due to excessive forcing is not usually continuous, and sometimes has to be permitted in order to tide over an emergency. Where it is continuous, the remedy is of course more capacity.

Moisture in the coal as it comes from the mines varies considerably, but for a number of mines in the Pittsburgh vein, this ran about 1.4 to 2.9 per cent from a number of mine samples taken. From mines in other seams of this district it ran from 3½ to 10 per cent. What it is when delivered at the boiler house depends on the time it was in transit and the weather conditions, but it usually contains more than the mine moisture. Additional moisture is often added before it is fired on chain-grates, and this is the moisture I refer to particularly. We have made tests which show that dampening fine slack fired on chain-grates so that the total moisture content was from 5 to 8 per cent, improved the efficiency and capacity as compared to firing the slack dry, but the great trouble with this is that too much water is likely to be put on. I have seen the coal literally soaked, so that the moisture which it contained ran from 16 to 20 per cent, and this is wasteful. Of course, theoretically, any moisture in the coal must be evaporated by the heat in the furnace, requiring 970 Btu per pound of water. Then each pound of water passes up the stack as superheated steam at the temperature of the flue-gas, and in this way any moisture carries away heat from the furnace. Therefore, adding water to coal would seem to be providing a means for carrying away heat uselessly. However, a small quantity seems at least with some coal, to improve combustion and prevent clinkers, and in this way the resulting benefits are greater than the actual heat loss caused by the water. However, it does not follow that increased benefit will result from increased water and, when water is used at all, it should be in such a way that the coal cannot be soaked.

The incomplete combustion loss is due to firing too much coal at one time; too thick a fire; clinkering coal and insufficient combustion space and temperature.

Firing too much coal at one time, is a practice that must be dealt with mainly with hand-fired boilers, as there is not much reason for trouble of this kind with stokers. I have seen so-called firemen put in over 700 pounds of coal in a furnace of a 300 hp boiler at one

firing, I verified this by counting the shovelfuls and weighing several. After this most interesting display of intelligence, the firemen will sit down and smoke for some time. Since the coal contains at least 35 per cent volatile matter, there was about 250 pounds of rich hydrocarbon gas in the furnace, a large part of which would be distilled off and passed up the stack without being consumed. Of course this is an exaggerated case, but it illustrates a practice which exists in many boiler plants. This is one great advantage of any good mechanical device used for firing; it feeds the coal gradually and continuously to the fire—something which it is almost impossible to make a fireman do in this district.

I do not know of any way to determine the proper thickness of fire for a given hand-fired grate or stoker, with the draft available, other than to run tests with different thicknesses and analyze the waste gas. Of course the ideal condition is very low oxygen, indicating minimum excess and no CO. This is true with any kind of fuel—coal, blast furnace or coke oven gas. It is usually impracticable to determine hydrogen or hydrocarbons in flue-gas, and it is assumed when there is no CO present, that combustion is complete, which may or may not be true. I fully believe that the heat loss due to incomplete combustion is much greater than indicated by the presence of a small quantity of CO, especially when the coal is not fired uniformly, because the CO indicates that there is incomplete combustion, and there is, therefore, a strong probability that hydrogen and the hydrocarbons which are not detected by the waste gas analysis are passing out unburned and these gases are very high in heating value.

Clinkering coal causes incomplete combustion, by the ash in the coal melting and forming a thin layer on top of the grate-bars, which prevents the air from passing through. The inexperienced firemen attempt to relieve this condition by free use of the slice-bar; pushing it under the fire over the grate and turning the fire upside down. This mixes the clinker among the burning coal, where it again melts and fuses the coal together, making a mess which will not burn at all. When using coal with an ash of this kind, fired on flat grates by hand, the less disturbance of the fire the better. As soon as the gates begin to cover over, the fire must be burned down as well as possible, and then cleaned. There is no use in trying to keep the grates open by using the slice-bar, as it only makes a bad condition worse. Such clinkering coal can usually be burned successfully on chain-grates by running a thin fire and letting the fire alone, cleaning any clinker, which does form, off the grate as it comes around.

As boilers used to be set, the space for the combustion of the gas above the fire was entirely too small. Sometimes the heating surface was not more than a foot or a foot and a half above the top of the fire. This results in the hot gases impinging on the comparatively cool heating surface of the boiler while they are in process of combustion, which lowers the temperature of the gas so that its combustion is not complete. This results in an extremely wasteful

condition, one evidence of which is the formation of smoke. We have tried various expedients to overcome this trouble, without actually resetting the boilers, which in most cases is either not practicable, or would be so expensive that the outlay would not be justified. We have in some cases changed the baffling on cross-baffled boilers to horizontal baffles, and lowered the bridge wall, thus utilizing the space back of the bridge wall for combustion. In this space piers and wing walls are built to serve the purpose of mixing the gases. The results are beneficial so far as the abatement of smoke is concerned and in improving combustion, but there is additional difficulty in keeping the surface of all the tubes clean on the outside and keeping the additional brickwork in repair.

However, all such changes are only expedients, to be adopted as such for the purpose of carrying over the boilers until such time as their age and condition require replacement. The importance of large combustion space and high temperature in that combustion space cannot be emphasized too much. One boiler company recommends, from investigations which they have made, two cubic feet of furnace space per rated horsepower, using blast furnace gas, and for coal $1\frac{1}{2}$ to $2\frac{1}{2}$ cubic feet of furnace space per rated horsepower. Another boiler company that has been developing larger furnaces has had good results from 3 to $4\frac{1}{2}$ cubic feet per rated horsepower.

High temperature in the combustion space and thorough mixture of the oxygen with the combustible elements are favorable features of the underfeed type of stoker using forced blast. I have always considered the principle of feeding the coal uniformly underneath the fire and burning it with forced blast as a most efficient means of using bituminous coal. This is indicated by a paper which I read before this society December 19, 1899 (Proceedings, Vol. 15, pages 333-360). When to this method of feeding and burning the coal is added large combustion space, so that combustion is nearly completed before the hot gases come in contact with any considerable area of the heating surface, the results are bound to be good—provided of course the boilers are kept clean and handled properly in other ways discussed herein.

I have discussed above at considerable length the losses which take place up the stack, as they are by far the most important and their reduction will effect the greatest saving. The loss in the ashpit must be dealt with in different ways, depending on the type of equipment used. With hand-fired grates, about all that can be done is to have the air spaces in the grates as small as is consistent with proper air supply. I like best the herringbone bar, with the air spaces not over one-half or five-eighths inch wide. With flat grates the most of the unburned coal falls through near the front end, where it is often possible to scrape out some of this before the fires are cleaned, and fire it over again. With chain-grates it is usual to extend the floor of the boiler room back under the grate about two-thirds its length, or put in reclaiming pans extending back this distance. All the unburned coal that falls through on this can be raked forward and refired.

FOREIGN RELATIONS

ADVERSE EXCHANGE AND AMERICAN IMPORTS INTO BELGIUM.

Trade Commissioner, C. E. Herring, Brussels.

It is of course unnecessary to point out the deterrent effect of present exchange rates on the sale in Belgium of United States products. At the prevailing rate (8.90 on September 23) Belgian purchasers of American goods are compelled to pay a premium of 72 per cent. This large addition to the f.o.b. factory price or to the c.i.f. price in Antwerp is a sufficient barrier to the importation of goods not vitally needing for the feeding of Belgium or for the rehabilitation of important industries. To this increase must be added a further increase due to the Belgian method of calculating import duties.

The Belgian importer is obliged to pay duty calculated on the exchange rate prevailing on the date of clearance through the customs. Goods arriving at a Belgian custom-house a considerable time after the opening of credits in New York or after the receipt of shipping documents may accordingly be subject to a considerable increase in duty because of the subsequent rise in exchange. This is, of course, a source of great inconvenience to the importer, and the risk involved in gambling in exchange is considerably augmented. Complaint has been made by importers of Swiss goods who have had to pay considerable premiums on this account, and the importers risk is, of course, much greater in the case of American goods, which are necessarily longer in transit.

British Trade Handicapped—Germany's Advantage.

While exchange as between Belgium and Great Britain is not quite so abnormal as the ratio between francs and dollars, it may be said that British export trade is handicapped almost as much as that of the United States. At the same time, the status of the third great industrial and exporting nation is greatly improved by present exchange conditions. The German mark is now (September 17) quoted at 31 centimes, with the result that whatever sentimental objections Belgian merchants may have to resuming trade with Germany, there is great commercial advantage in obtaining necessary supplies from their former enemies.

At the present rate of exchange, for instance, the Belgian importer of paper goods would pay 148 per cent more for the privilege of purchasing his supplies in the United States rather than in Germany, assuming the basic price to be the same. In other words, the purchaser would lose 73 per cent by reason of the high rate of dollar exchange (8.90) and he would gain 75 per cent by purchasing mark exchange at 0.31. As before indicated, he would be apt to sustain a supplementary loss on account of customs duties payable on United States products, while he would be apt to make a corresponding gain in the case of German imports because of the probable further decline of the mark.

France and Italy Not in Position to Grasp Opportunities.

If France or Italy were in a position to supply the manufactured products and raw materials needed by Belgium, commercial as well as sentimental considerations would pre-dispose Belgian importers to make such purchases, as French exchange is practically at a parity with Belgian exchange, and the lira is at a considerable discount. With these countries not yet in a position to resume the export of manufactured goods on a large scale, however, and with the heavy premium which must be paid in connection with American and British goods, it is almost inevitable that German products will be welcomed, despite natural prejudice.

There is considerable controversy as to the policy which should be followed by the Belgian government in connection

with the importation of German products. Merchants are naturally more anxious for the re-establishment of free commercial intercourse than are the manufacturers, who have not forgotten the price competition of the German cartels in pre-war days. At present an import license covering German products must be obtained, but where the goods in question do not compete with Belgian products, or where they are needed in connection with the restoration of industrial plants, the tendency is to grant licenses readily. With the continued decline of the mark in relation to the franc, there will, of course, be an increased tendency toward the removal of present restrictions.

While exchange conditions are undoubtedly of great benefit to German manufacturers and exporters seeking to regain their pre-war foreign markets, it must be remembered that Germany must buy as well as sell with a greatly depreciated currency. The tremendous premium which German manufacturers must pay for all raw materials and semi-manufactures from abroad will inevitably be reflected in the price of their products. This together with the large wage increases and abnormal depreciation of plants during the war will greatly increase the costs of production in Germany.

Where raw materials purchased abroad are an important item in production, it seems probable that for some time German export prices must exceed those prevailing in the United States and Great Britain. American manufacturers should therefore have a comparative advantage in cost of production, which to some extent would offset the disadvantage of the present exchange situation. Even making liberal allowances for price increases in Germany, however, Belgian importers will probably find it more profitable to purchase there until they are able to buy dollars at a figure considerably nearer par.

BRITISH METHODS OF FINANCING SALES TO GERMANY.

The following cablegram was received from Commercial Attache Paul M. Edwards at The Hague, Netherlands:

British exports to Germany are at present suffering a severe slump. Principal underlying reasons are: (1) The slump in German exchange; (2) the present uncertainty as to whether stocks now lying at Rotterdam, Cologne, and elsewhere will be subjected to German import control and gold duties; (3) the congestion at Rotterdam and Cologne making deliveries uncertain.

Most exports are now being sold cash on delivery at German port. Under these circumstances, British and other banks at present are financing practically no stocks or new shipments at full value. From best information obtainable here and at Cologne, it appears that British exporters are now bearing the entire risk of practically all shipments to Germany.

GERMAN TRADING METHODS TO MAINTAIN VALUE OF MARK.

Consul General Soren Listoe, Rotterdam, Netherlands.

One of the methods employed by Germany to maintain the value of the German mark and prevent its exportation to neighboring countries, where the rate of exchange would militate against the business interests of the present confederation, appears to be the continued "turning over" of manufactured articles for goods of higher value, but which barter is rarely placed upon a dollars-and-cents basis.

For example, Germany at the present time is greatly in need of boots and shoes, but has not the hides to employ for the purpose.

PRODUCTION TOPICS

FORGING TEMPERATURES AND RATE OF HEATING AND COOLING OF LARGE INGOTS.

(Continued from page 565)

temperatures. The question is a difficult one to settle, however, as it depends on a number of variables.

It is difficult, if not impossible, to calculate the stresses set up at any one point in an ingot, due to unequal expansion, and in that way determine what the maximum allowable difference in temperature between the outside and the center will be. If this could be done, it would be a simple matter to prescribe the rate of heating that any size ingot should have. The main source of information is the experience of steel men through years of practice on forging large ingots.

The result of the test show that an optical pyrometer can be used to determine when an ingot is ready to forge. To make sure that there is no error due to loose scale or ash, it is well to push a bar in the furnace and clean the spot on which the pyrometer is to be sighted. This being done, if the surface temperature is 100 degrees F. higher than the temperature at which it is desired to forge, the ingot is ready to pull out. For instance, if the forging temperature is 2,250 degrees F. (1,232 degrees C.), should the optical pyrometer read 2,350 degrees F. (1,287 degrees C.), the ingot is ready to forge. The outside temperature of the ingot will drop very rapidly in the air and leave the center the hottest portion; for a 24-inch ingot, the difference between the outside and center is about 100 degrees F.

The optical pyrometer can be used to determine gas temperatures approximately by sighting on the bricks of the back wall or by sighting on a target or in a tube. Usalite porcelain stands the forging-furnace temperature very well and quickly changes temperature with the gases, as will a target of thin metal. The target, however, does not stand the corrosive action of the gases for any length of time, a nichrome target lasting to a temperature between 2,200 degrees F. (1,204 degrees C.) and 2,300 degrees F. (1,260 degrees C.). The error due to making a reading through a light flame is approximately 20 degrees F. Readings through light ash from a powdered coal flame, with an optical pyrometer, do not appreciably affect the temperature read.

A couple on the surface of a large ingot may indicate a temperature approximately that of the gas and much above that of a point in the steel $\frac{1}{2}$ inch under the surface.

The temperature gradient along the ingot from the door to a short distance inside the door is very large and must create serious stresses at that point.

From the rate of cooling of the 24-inch ingot, it appears that it can be worked for two hours without working it too cold. This may not actually be the case as the thick scale drops off and the piece is worked down to smaller dimensions where it will cool more rapidly. On the other hand, working heats the piece and will tend to counterbalance more rapid cooling.

The amount of coal used in this test was approximately 0.25 lb. per pound of steel. The average amount of coal used for production work at this plant was 1 lb. per pound of steel. This shows that the furnaces can be fired much more efficiently.

In conclusion the writer wishes to thank G. R. Norton and R. C. Drinker for their hearty cooperation and interest in this investigation.

BUREAU OF SHIPPING APPROVES WELDING PROCESS FOR MARINE REPAIRS.

An important development of thermit welding in American shipyards is anticipated by the recent approval by the American Bureau of Shipping of the thermit process for welding stern frames, rudder frames, and other heavy sections on ships registered under their classification. The only qualification is that this bureau be notified sufficiently in advance to have a surveyor in attendance during the welding operation as well as to inspect and test the weld when completed.

While the thermit process has been used since 1903 for making marine repairs and has a great many successful welds of this nature to its credit the process was never officially approved by the American Bureau of Shipping and most of the repairs were made on vessels not classed by them. It is due entirely to the unbroken record of successful marine welds that the bureau now accords its official sanction to the process. According to a statement by the Metal & Thermit Corporation there has never been a single failure of a thermit marine weld so far as it has been able to ascertain in all the years that the process has been used under this company's jurisdiction.

Now that the United States promises to have one of the largest mercantile marines in the world, and as practically all of the ships which have recently been constructed, and which will be constructed in the future, will be registered with the American Bureau of Shipping, the recognition of the thermit process by that bureau bids fair to result in many important thermit marine welds from now on.

A CORRECTION.

On page 479 of the October issue of THE BLAST FURNACE AND STEEL PLANT the following cut caption appeared: "A worn blooming mill pinion repaired by the arc welding process. The white lines show the original outlines, the metal outside having been added. The cost of repairing four ends (two pinions) was \$170. The pinions cost \$1,000 each and could be saved by no other process." It was not intended to give the impression that this repair could be made solely by arc welding. The repair can also be made by other welding methods such as the thermit process. The caption conveys the proper idea if the word "arc" is omitted.

A. C. STARTING SWITCH.

It is permissible to start induction motors up to and including 5 hp, and in some localities up to and including 7½ hp, by merely connecting the motor to the power circuit. Small induction motors can be started under these conditions without injury. In the past it has been customary to start these motors by simply closing a knife switch, or a switch similar to a knife switch. For the man who wanted something better, he could buy a switch which would short circuit the fuses while the motor was starting, and then after the motor had come up to speed, the operator could make a second motion with a starting switch; insert the fuses in the motor circuit, to be used while it was running.

A new device for this kind of work has just been developed by the Electric Controller & Manufacturing Co., of Cleveland, O., to make the starting of these motors fool proof. It is known as the ac starting switch, and is operated by a push button. It is inclosed in a steel box with conduit connection for all wires. A neat compact push button arranged for conduit connection, is supplied for "starting" and "stopping" the motor.

Particular attention is called to the two wires extending the length of the slate on the lefthand side. These wires gives overload protection of the inverse time element type, both while the motor is starting and while it is running. The principle used is one entirely new in motor starting practice. These two wires are stretched, and the operating value of this overload protection is adjustable by changing the tension of the wire. If too much current is being taken by the motor, these wires will expand, causing the small contact at the bottom to be open and this will in turn, de-energize the magnet coil and cut the motor off the power line. It is then necessary to push the start button before the motor can again be started.

INDUSTRIAL RELATIONS

CAN YOU GET PAST YOUR FOREMAN?

By W. R. BASSET,

Miller, Franklin, Basset & Co.

Do you know what your workmen call you?

"The Boss."

And what they call the department foreman?

"The straw-boss."

That's quite a sidelight upon how they regard foremen—as one with a mere resemblance to the real thing, without being of the real substance—men of straw!

Ask an ex-private of the A. E. F. who it was he swore to kill just after getting his discharge, and he will tell you, "the top sergeant."

For the commissioned officers over him, it's a safe guess, he has little but good to say. His captain looked out for his welfare and treated him well, for it's usually an attribute of those accustomed to giving orders—to ruling, if you will—to give reasonable orders, to be reasonable, and approachable. They have learned to give orders in a way and a tone which is inoffensive.

It's the non-commissioned officers, those but lately raised above the run of men who are at least considerate of their late equals.

They seem to feel that to be obeyed they must give orders in an overbearing offensive way. They are not sure enough of the newly achieved authority to assume that obedience will follow an order.

What is true of an army is true in a factory. A foreman comes from the ranks of workmen and fears usually that Tom and Bill, with whom of late he fraternized, will not take orders kindly from their old pal. So to add effectiveness, the new foreman removes himself from familiar contact with them, wears a forbidding frown, and adds a bit too much tone of authority to his orders. Perhaps there is too, just a little desire to "rub it in."

Whatever the mental processes may be, it is certain that between the stockholders of an enterprise and the men in the shop the foreman provide the greatest barrier. In fact at this point, there is both a barrier to be overcome and a gap to be jumped.

Strange to say, but little effort is made to close up that gap and to lower the barrier. Owners hold conferences as a matter of course with superintendents. They in turn commonly hold "foremen's meetings" at which they, with considerable success pass their ideas along, and find out what the foremen think their men are thinking.

But the foremen seldom unbend to their subordinates. So, for lack of the contact between men and foremen, the policy of the owners seldom gets to those who can make or break the business.

How often have owners seen conditions clearly for the first time, when visited by a committee of striking workers!

It is partly a realization of this fact—a sub-conscious realization of it I believe—which has led a few clear-seeing owners to organize their plants under a form of industrial democracy.

Some have gone so far as to give the men a say in the management of the plant—while giving the foremen no say. Others have the workmen elect from their own number a "house of representatives," while the foremen elect a "senate." Either way is good.

The point is that workman representation gives the men an opportunity to jump the gap, to climb over that barrier between themselves and the management—and so to get their ideas, needs and viewpoint to the owners with no danger of being stopped by petty foremen.

With the assurance that they can speak freely without hurting themselves, the men offer many suggestions that improve production and reduce costs. The trouble has been in the past that

their suggestions have often not been welcomed by the foremen and the only way the workmen could get the ear of the management was through the foremen.

You may feel that it is not yet safe to give the workmen a chance to help you manage. Perhaps you don't believe they have much to offer. But you certainly must wish your men could know how decent a chap it is they are working for.

So, if you don't want to put in a plan of industrial democracy, you can at least let the men elect committees to confer with you—thus jumping the foreman barrier.

Foremen cannot be eliminated. Direct supervision is needed and foremen must give it. They must also be teachers and sometimes disciplinarians, but they should never be barriers.

A manufacturing business should not be a steeplechase course. It should be a smooth track with no obstacles between the men and the manager.—From *Sphinx Talks*.

SWISS MISSION VISITS WESTINGHOUSE PLANTS.

On Friday, October 3, the Westinghouse plants at East Pittsburgh and Wilmerding, were honored by a visit from the Swiss mission for economic studies in North America.

This mission is visiting various cities in the United States and Canada, for the purpose of studying American methods and practices, in order that they may apply these methods where practical to their own business.

The mission was met in Pittsburgh by representatives of the Westinghouse Airbrake Company, and the Westinghouse Electric & Manufacturing Co., and escorted to Wilmerding on special car attached to one of the regular Pennsylvania Railroad trains.

Upon the arrival of the train at Wilmerding, the party was met by officials of the Airbrake company and was given a serenade by the Westinghouse Airbrake band. A decided hit was made with the members of the mission by the band when it played the Swiss National Anthem.

Following the reception a trip was taken through the airbrake works, where the various processes involved in the manufacture of the airbrake were explained in detail to the visitors, who expressed much interest in the manufacturing methods pursued by the company.

After completing the inspection tour, the party was escorted to the welfare building, where luncheon was served. Immediately following the luncheon A. L. Humphrey, of the Airbrake company welcomed the visitors, and turned over the meeting to W. S. Bartholemew, vice president of the Airbrake company, who extended a further welcome and told of some of the activities of the company in the manufacture of railway equipment.

Response was made to these addresses by Commissioner Zweifel, of the mission, who expressed his very great appreciation of the reception tendered the mission, and also took occasion to say he felt very much at home in this locality, because the hills surrounding East Pittsburgh and Wilmerding reminded him of his native haunts in Switzerland, a remark which caused much merriment among his hearers. He also took occasion to say that the Westinghouse interests need no advertisement, as every man, woman, and child in Switzerland know Westinghouse from having seen it on the airbrakes which are used on all of the trains in Switzerland.

The visitors were then escorted by the band to the trolley station in Wilmerding, where special cars were awaiting to take them to East Pittsburgh. On their arrival in East Pittsburgh, the visitors were met by Acting Vice President T. P. Gaylord, and other Westinghouse officials, and a number of guides speaking French and German, both of which languages are extensively used in Switzerland.

The visitors were then shown through the immense electric and machine works constituting the East Pittsburgh plant, a picture being taken of them as they passed from the electric over to the machine works.

NEWS OF THE PLANTS

The Eastern Rolling Mill Company, Baltimore, Md., has inaugurated construction work on its proposed new plant at Canton, near Baltimore, and plans to have the first unit ready for occupancy and operation by the first of the year. The initial construction work will be on the main building, a steel-frame structure, 360 x 1,000 feet, estimated to cost \$500,000, including machinery installation. The plant will consist of 12 mills, and six of these will be erected at the present time. The remainder will be placed under way at an early date, and will be ready for service about March. The plant will specialize in the production of steel products for automobile use, and is expected to give employment to about 1,400 men for initial operations.

The Reliance Wheel Company, Youngstown, O., recently organized with a capital of \$100,000, to manufacture double-disc pressed steel wheels for automobiles, has acquired a local site, comprising about five acres, for its proposed new plant. The property is in the vicinity of the works of the General Fireproofing Company, on the main line of the New York Central and Erie railroads. Surveys have been made for the initial plant, which will consist of a large factory, to be fully equipped in all departments of production. It is expected to have the plant completed and ready for service before the close of the year. Joseph M. Crenan is president.

The Canonsburg Steel & Iron Co., Canonsburg, Pa., is planning for the erection of additions to its plant for increased capacity, to consist of two new hot sheet mills, and auxiliary operating facilities.

The New England Iron Works, 94 Commerce street, New Haven, Conn., has broken ground for the erection of its proposed new plant for increased production. The new works will be located on Dixwell avenue, Hamden, and will comprise two structures, a two-story building, 25 x 35 feet, and a one-story iron-working shop, 62 x 150 feet.

The La Belle Iron Works, Steubenville, O., is now operating its new by-product coke plant, Koppers type, on the south bank of the Ohio river, opposite its main works. The plant comprises four water-tube coolers, tar extractor, reheater saturator, ammonia still, benzol scrubbers and other miscellaneous apparatus. There are two continuous stills for benzol vapor service and a condensing still for the fractioning of light oil into crude benzol, crude toluol and other products. Four purification stills, each with capacity of 8,000 gallons are provided for the production of pure products. A power plant has also been constructed, comprising a separate plant unit, equipped with four 400 horsepower water-tube boilers of Sterling type; the boilers are arranged for burning either gas or coke breeze under forced draft. A large pumping plant has been provided, with installation consisting of 20,000 gallon units of Gould type; three of these have been installed, as well as a 10,000 gallon pump for tar loading operations. A complete coal-handling system has been provided, giving exceptional efficiency in operation.

The J. E. Moss Iron Works, Wheeling, W. Va., is planning for the erection of additions to its plant for increased operations. A new three-story building, 25 x 100 feet, will be erected, and a one-story addition, 120 x 240 feet. The site is located at Market and Twenty-eighth street. The expansion is estimated to cost about \$100,000.

H. Boker & Co., Inc., 101 Duane street, New York, manufacturer of steel products, is having plans prepared for the erection of its proposed new plant on property recently acquired on Burnett avenue, Hilton, N. J. The initial works will consist of a number of buildings, to form a first plant unit. The main

building will be three-story, 135 x 135 feet, with adjoining one-story structures, 75 x 135 feet, and 50 x 80 feet. A pickling works will be installed, as well as a power plant for works operation. The various buildings will be of reinforced concrete, and the plant is expected to give employment to about 500 men on the inauguration of production.

The recently-constructed plant of the Tennessee Coal, Iron & Railroad Co., at Fairfield, Ala., is now engaged in the production of steel for use in the construction of fabricated steel vessels at the new shipyard at Chickasaw, Ala. The plant comprises plate, bar and structural mills, with a number of other operating structures. The plate mill is 36 x 110 inches, and adjoins a large bank of reheating furnaces; the bar and structural mill is of combination type, and is supplemented by a hot-bed department. The various shop buildings include, in addition to those noted, a plate and shape fabricating shop, forge shop, machine shop, power plant, physical laboratory building, 45-inch blooming mill, stripper building and other structures. A complete system of craneways has been installed, reaching to all parts of the plant.

The Lancaster Steel Products Company, Lancaster, Pa., has perfected plans for extensions to its works to increase the annual output by about 15,000 tons of steel. Additions will be erected for this enlarged capacity, including a one-story building, with bar mill extension, 50 x 310 feet, and 50 x 70 feet, respectively.

The Ingalls Iron Works Company, Birmingham, Ala., is completing improvements at its plant for increased capacity and improved operating facilities. The company contemplates the erection of a number of additions at a later date to allow for further increase in output. The plant specializes in the production of structural steel of all kinds for building construction, and is devoting considerable capacity for export materials.

The Lake Huron Steel Corporation, Toronto, Ont., has completed preliminary details for the erection of its proposed new plant. A site has been acquired at Goderich, Ont., and surveys are now under way for the new mill. The property consists of about 250 acres, fronting on Lake Huron, in the southern part of the city. The initial works are estimated to cost about \$2,000,000, and will comprise a number of electric furnaces and other special equipment for the production of high-grade steel products. At an early date it is planned to enhance the present plant, as now arranged, by a number of extensions and facilities to cost in excess of \$5,000,000. Among those interested in the new company are J. C. Jones, president of the Cleveland Steel Company, Cleveland, O.; Charles R. Talbot, vice president National Bank of Commerce, Detroit, Mich., and C. F. Megow, president of the Charles Megow Tractor Company, St. Paul, Minn.

The Nova Scotia Steel & Coal Co., New Glasgow, N. S., is planning for the erection of a new by-product coke works in the vicinity of its Sydney mines, Sydney, N. S., to cost about \$2,000,000, including equipment installation. In addition to these new ovens, the company is also considering the erection of other plant extensions, including a new blast furnace.

The Southern California Iron & Steel Co., Los Angeles, Cal., is planning for the erection of a new steel and iron plant on property recently acquired at Huntington Park, near Los Angeles. The tract comprises about 25 acres, and will be used for the erection of a large group plant, consisting of open hearth furnaces, forge shop, rivet works, galvanizing works and other buildings. The plant is estimated to cost about \$1,500,000.

Some Pointers on By-Product Coke Oven Operations

TAR EXTRACTOR IMPROVEMENT SUGGESTIONS. (Continued from page 545)

opening the tar drain cock leading to the tar drain column and tar seal. When the tar is drained to the level of the lowest regulating cock the gas is shut off and the extractor drained of tar and steam turned in to melt down the pitch and naphthalene clogging the extractor bells. This completes a cycle of operation and the extractor is ready for operation again if the steaming out operation proves effective, and though occasions are rare when steaming out is not effective it sometimes happens that if solid particles have been drawn from the ovens with the gas they lodge in the extractor bells and cannot be removed by steaming out. The extractor bells must then be removed from the shell, taken apart and scraped. This is a very difficult task and the reassembly is even more so, there being considerable danger of disalignment of the bell plates.

Much effort has been spent on proposed improvement of this type of extractor but without success, and though the principle of design is correct under operating conditions the extractor has decided limitations.

In the design of the tar extractor represented in Fig. 2 the same common principle of design and construction is applied as has been applied to gas apparatus heretofore mentioned, but in addition the fundamentals of compactness, accessibility, instantaneous pressure regulations and continuity of operations which are lacking in the usual extractor design, are fully met in this construction.

Fig. 2 shows a longitudinal sectional elevation and a cross sectional elevation of this extractor. The casing is preferably of cast iron of the outlines shown. The extractor wheel is hung from two adjustable bearings suspended by brackets projecting into the center of the extractor from the inside of the extractor cover. The extractor wheel is mounted on this shaft and turns with and by it, the driving being done by means of a pinion and gear, the latter being keyed to the end of the shaft nearest the gas outlet and the pinion being carried by a stem running through a packing gland on the cover. This stem is further driven by a worm gear and worm, the worm shaft being driven by a tight belt pulley, a loose pulley being mounted on the outer end of the shaft. The belt running on these pulleys is thrown from the loose to the tight pulley when the gas pressure rises on the inlet end of the extractor wheel by reason of the momentary clogging of this wheel. The slightest increase in pressure acting through the pressure regulator valve admits steam or compressed air to a cylinder. This operates the piston which, acting through the belt throw lever, turns over the extractor wheel.

That part of the wheel which had been standing immersed in the tar bath in the lower part of the casing slowly turns up out of the bath exposing clean and unobstructed openings through which the gas may pass. When the gas pressure is thus relieved the pressure regulator returns to its normal position reversing the action of the piston in the steam or air cylinder. This in turn throws the belt throw lever in the direction of the loose pulley taking the belt with it and stopping the motion of the extractor wheel.

No reduction of gas pressure below normal will take place in this design of extractor as the tar level is maintained at a permanent level and the gas passages are never increased by revolving the wheel; the only action taking place is that of cleaning the plate surfaces of the extractor wheel. This action is similar to that of raising the bells of a P and A out of the tar bath except that as above stated—no additional gas passages are opened.

When the extractor wheel becomes so clogged that the gas pressure rises constantly causing the pressure regulator to keep the extractor wheel continually in motion the attendant does not shut down the extractor, but simply opens the steam cocks

leading to the steam out nozzles which are placed beneath the tar level and close to the ends of the extractor wheel. The steam in entering the tar bath is quickly condensed, but the force of the onrushing steam forces the quickly heated tar between the surfaces of the extractor plates. One steam nozzle forces the tar through the extractor plates toward the gas outlet end of the extractor wheel while the other nozzle forces the tar in the opposite direction, thus a balanced steamout operation occurs in the shortest possible time and without shutting down the extractor.

Should it become necessary to remove the extractor wheel from the casing for the purpose of cleaning, it can be quickly accomplished, and as the wheel will occupy so little storage space compared to the extractor bells, a spare may be kept on hand and may be immediately inserted, thus necessitating a minimum shutdown.

The extractor wheel is made of the usual corrugated sheets of the smaller pitched corrugations and indented as shown in the detail of extractor wheel plates in Fig. 2. The indentations are of such depth to accomplish the spacing of the plates 1/16 inch apart. The plates are freely perforated with holes about 1/8 inch diameter to allow of tar circulation, but neither holes nor indentations must follow any strict alignment.

For an extractor with a gas inlet and outlet of 36 inch diameter the diameter of the extractor wheel would not be more than 36 inches and that of the central blank core of 12 inches with the tar level approximately as shown in Fig. 2. The length of the wheel would not be more than 12 inches from the inlet to the outlet end.

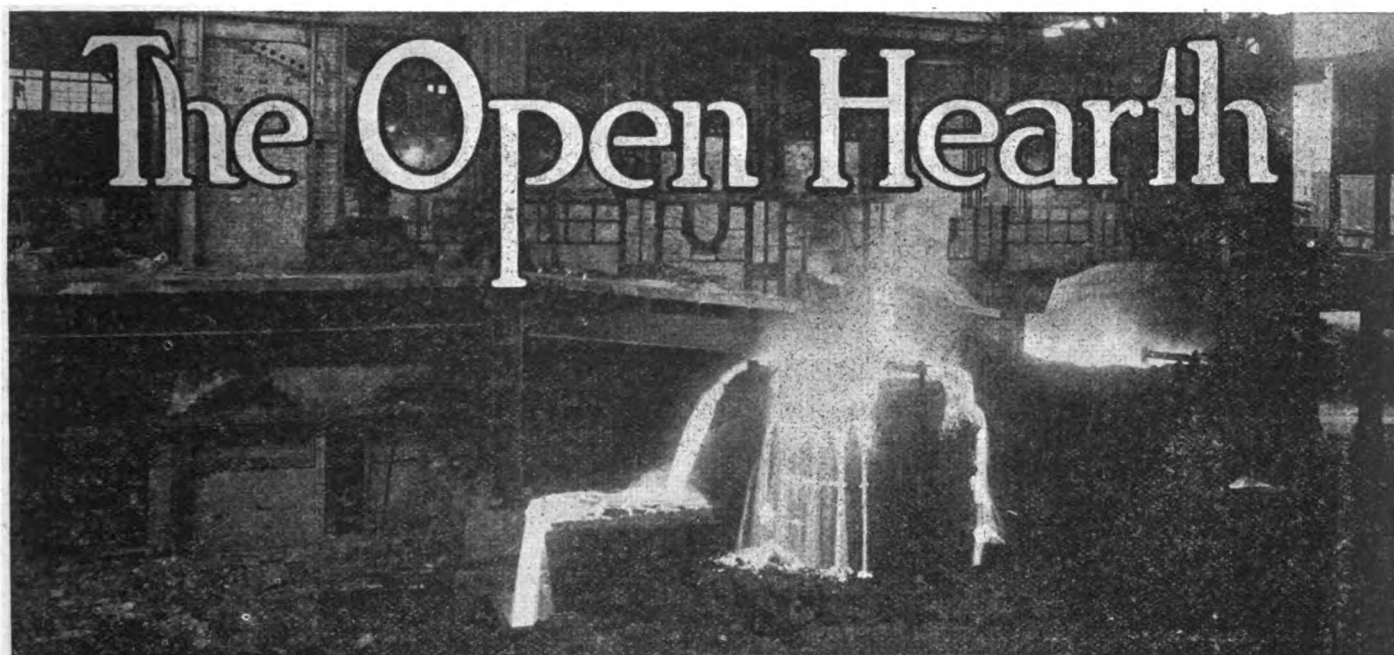
It will be noted from the description of both types of tar extractors that they differ from most other gas apparatus in that the gas instead of being allowed to expand and travel slowly through the apparatus is confined in the extractor to small passages and the velocity of the gas in passing through the apparatus is thus greatly increased. The baffle areas as a consequence are also less for this reason.

The gas in passing through the extractor, Fig. 2, enters the inlet and the entire sectional area instantly strikes the thin edges of the extractor wheel plates which splits up the gas volume into films 1/16 inch thick. These films are hurled rapidly against the corrugations of the plates. They are further split up by each indentation of the plates which occur frequently in the path of the gas films on their way through the extractor wheel. The impact of the gas on these surfaces impinges the tar on them.

As the gas pressure between all plates is equal at all points in the wheel equidistant from the inlet or outlet end of the wheel there can be no deformation or bulging of the extractor wheel plates as sometimes occur with the bell plates of the P and A extractor.

The further advantages of the wheel type extractor are automatic control, instant adjustment of gas pressure, longer operating period without necessity of steaming out and the possibility of steaming out without the necessity of shutting down the extractor. Without consideration of the tar seal the wheel extractor occupies about one-third the height occupied by a P and A of equal capacity and practically no additional head room is required for removal of the wheel from the casing.

It is also possible to operate this extractor on the suction end of the exhauster where it might be desirable to remove the tar before the gas entered the exhauster. It may be installed in the gas inlet of a gas engine for removal of final tar from gas before it enters the engine cylinders. In an installation of this kind an oil pitch solvent would have to be used instead of the tar bath especially if producer gas is handled on account of the heavier or less fluid nature of the tar or pitch to be removed from the gas. Operating on suction, however the inlet of the extractor becomes the outlet end and the outlet end the inlet.



Evan F. Jones on November 1 took up his new duties as general manager of the Elyria Iron & Steel Co., with works at Cleveland and Elyria, O. He was president and general manager of the Clinton-Wright Wire Company, Worcester, Mass., at the time he accepted his new position. Sometime during the first part of November the election of his successor by the directors is expected to take place, and at this time the stockholders will meet to decide upon a new name and upon increasing the number of directors. Until the election of a president, the affairs of the wire company will be directed by Harry W. Goodard, chairman of the board of directors.

✓ ✓

Edward O. Werba has become affiliated with the Meriden Iron Company, Hibbing, Minn.

✓ ✓

W. H. Schoen was recently elected president of the Pittsburgh Knife & Forge Co., Pittsburgh. He succeeds P. A. McBride.

✓ ✓

H. G. Hilton is now connected with the Steel Company of Canada, Hamilton, Ont. Until recently he has been associated with the United Furnace Company, Canton, O.

✓ ✓

C. E. Hutchison is now associated with the Cleveland office of the Youngstown Sheet & Tube Co., Youngstown, O. He was formerly district representative of the La Belle Iron Works, St. Louis.

✓ ✓

George M. Johnstone has been promoted to production manager of the Clinton Wire Cloth Company, division of the Clinton-Wright Wire Company, Worcester, Mass. He was formerly store manager of this concern.

✓ ✓

A. J. Hazlett, on November 1 assumed his new duties as general manager of sales of the Eastern Rolling Mill Company, Baltimore. For nine years, Mr. Hazlett had been in the sales department of the West Penn Steel Company, Brackenridge, Pa.

✓ ✓

Merrill Baker, vice president of the Vanadium Corporation of America, New York City, recently sailed for Peru where he will investigate the company's ore properties there, in connection with its plans for plant and transportation improvements.

✓ ✓

W. W. Leck recently became the new general superintendent of the American Tube and Stamping Company,

Bridgeport, Conn. Mr. Leck had been general superintendent of the rolling mills at the Steelton plant of the Bethlehem Steel Company, and will be succeeded by his assistant, John Craig.

✓ ✓

Ora J. Fish, for a number of years, second vice president and secretary of the American Shipbuilding Company, Cleveland, recently resigned. Both offices will be filled at a subsequent meeting of directors.

✓ ✓

H. H. Outwater has joined the selling staff, after being transferred from Buffalo to the New York office of Rogers, Brown & Co.

✓ ✓

L. Riese has been placed in charge of the San Francisco office of the Republic Iron & Steel Co., Youngstown, O., recently reopened.

✓ ✓

Samuel E. Stephenson was recently elected president of the Commercial Bank, Jackson, O. He was formerly connected with the Wellston Steel & Iron Co., Wellston, O.

✓ ✓

Alvin H. Klemme has been made factory manager of the Remmert Manufacturing Company, Belleville, Ill., maker of locomotive washing machines. He was formerly secretary of the Eagle Foundry Company of Belleville.

✓ ✓

A. C. Allshul has been transferred to Buffalo to take charge as branch manager of the warehouse of the Joseph T. Ryerson & Son, Chicago. He was formerly in charge of the Milwaukee district offices of that company.

✓ ✓

B. H. Reddy, formerly chief engineer of the National Pressed Steel Company has resigned to take up new duties with the Southern California Iron & Steel Co., Los Angeles, Cal. Mr. Reddy was at one time superintendent of the Bowler Foundry Company, Cleveland.

✓ ✓

Conrad B. Rubery, who for several years was in charge of production at the plant of the Heppenstall Forge & Knife Co., Pittsburgh and later resigned to take charge of shell steel production in the United States for the British munition commission, has been appointed works manager of the Sizer Forge Company, Buffalo, N. Y.

✓ ✓

J. B. Childe has been promoted to take charge as general manager of the Perfection Spring division of the Standard Parts Company. He was formerly general manager of the



Canton spring and forge plants of that company. H. E. Clay succeeds Mr. Childs as general manager at Canton. He formerly was plant manager of the Perfection plant, and later became production expert. He recently supervised the construction of the company's new spring plants at Flint and Pontiac, Mich.

✓ ✓

Philip L. Getzinger was recently made manager of the Chicago branch of the Vulcan Crucible Steel Company, with offices at 16-18 South Clinton street, Chicago. He was formerly connected with Edgar Allen & Co.

✓ ✓

B. F. Harper has associated himself with Roland T. Meacham, Guardian Building, Cleveland, investment broker. Mr. Harper was formerly connected with the sales organizations of the Republic Iron & Steel Co., and the Ft. Wayne Rolling Mill Corporation, Fort Wayne, Ind.

✓ ✓

Hugo Ritter Von Wessely, vice president and treasurer of the Rowe Calk & Chain Co., Plantsville, Conn., has resigned and will return to Austria, where his mother resides. He had been connected with the company for eight years.

✓ ✓

S. W. C. Fitts, who for two years has been superintendent of the Worcester Stamped Metal Company, Worcester, Mass., resigned to accept a similar position in Los Angeles. Victor Carlstrom of the Wire Wheel Company of America, Buffalo, will succeed Mr. Fitts.

✓ ✓

L. F. Loftus, formerly assistant engineer Pittsburgh Steel Products Company, and formerly with the Koppers Company has resigned his position to become engineer purchasing agent of the B. F. Goodrich Company at Akron, Ohio.

✓ ✓

F. J. Buller accepted the position of vice president and manager of the Canadian Steel Tire & Wheel Co., which will establish a large plant for the manufacture of locomotive and passenger car wheels at Montreal, Que. Mr. Buller recently resigned as treasurer of the Canadian National railways.

✓ ✓

Truston P. Draper has been appointed general superintendent in charge of operations in all of the properties of the Sharon Steel Hoop Company, Sharon, Pa. He succeeds

George W. Short. For some years, Mr. Draper was associated with the Republic Iron & Steel Co. in various capacities in its blast furnaces, steel plants and rolling mills. He was later connected with the Inland Steel Company, at Indiana Harbor, as assistant general superintendent following which he held a similar position with the Youngstown Sheet & Tube Co. Until recently, he has been identified with the Trumbull Steel Company, Warren, O.

✓ ✓

George W. Goethals, builder of the Panama Canal, has been elected president of the American Ship & Commerce Corporation, New York, Kermit Roosevelt, son of the late ex-president Theodore Roosevelt, is secretary of the corporation.

✓ ✓

F. M. English has been appointed district sales manager in charge of the sales office recently established by the Reading Iron Company of Reading, in Pittsburgh. The new Chicago branch sales office is in charge of R. A. Griffin as district sales manager. Craig Geddis has been appointed advertising manager for the company and W. E. Cunham is production manager.

✓ ✓

E. C. Morse has been made director of sales of the War Department, Wash., following the resignation of C. W. Hare. Mr. Morse was formerly assistant director of sales.

✓ ✓

George S. Hewins has become general engineer in charge of construction of the system of the New England Power Company, with headquarters in Worcester, Mass. He was formerly general manager in the construction of ships for the United States shipping board at the yard of L. H. Shattuck, Inc., Portsmouth, N. H. while the United States was in the war. Mr. Hewins succeeds Col. George W. Bunnell.

✓ ✓

Joseph H. S. Lynde, formerly supervising and safety service engineer for the Worcester Pressed Steel Company, Worcester, Mass., resigned, to accept a position of great responsibility with the American Tube & Stamping Company, Bridgeport, Conn.

✓ ✓

P. R. Thurston, formerly with Westinghouse Airbrake Company, at Wilmerding, Pa., is now connected with the Ludlum Steel Company, Pittsburgh district sales office.

WITH THE EQUIPMENT MANUFACTURERS

ELECTRICAL OPERATION OF GATE VALVES.

The Cutler-Hammer Manufacturing Company has recently issued a booklet containing a paper read by Peter Payne Dean, before the American Society of Mechanical Engineers entitled "Electrical Operation of Gate Valves." The paper discusses the application of electrically operated valves and describes the principle of the Dean valve. Mr. Dean classifies types of power operated valves as follows:

There are three types or kinds of power operating devices for gate valves, namely, hydraulic, electric and the water motor. Piston or hydraulic cylinder valves may be used with steam, air or water, the last medium being considered best for general purposes. The cylinders are of cast iron, brass lined, carrying the ordinary hydraulic plunger and pressure is admitted either above or below the piston by a four way cock or valve. Remote or distant control of these valves is obtained by using magnetically operated control valves, connected to a source of current such as a power circuit or batteries.

In case of failure of water pressure, provision is sometimes made to attach a stem and yoke so that ordinary hand-wheel operation can be secured.

While this type of valve is extremely simple in construction and operation, it is not suitable for outdoor usage on account of the freezing of the liquid. Further, the cylinder cannot be applied to existing hand operated valves, and on account of the size of the cylinder, takes up considerable room.

In filter installations and places where no electric power is available, they are of course ideal.

The water motor has been used in this country to some extent, but not to any marked degree of success. This type of motor consists of an ordinary Pelton wheel encased in a cast iron casing and supplied by pressure from the water main itself. The wheel is of the non-reversing type and in order to operate the valve in both directions, an ordinary reverse gear is arranged which has to be manually operated.

This valve also freezes unless it is drained, and further, it is very cumbersome on account of its size. It is not applicable to existing valves without considerable alteration and since it has no limit means to disconnect the power when the valve is seated, it frequently jams. Furthermore, it cannot be controlled from a distance.

Electrical operation by the aid of a motor geared to the valve stem and a limit switch for stopping the movement, is by far the most reliable method, but of course presents more of a problem.

The principal problem in this, or as a matter of fact in any other system of power operation, is to confine the movements of the valve gate to within very precise limits, especially at the closed position. On account of the momentum or over-travel of the motor armature and driving gears, after it has been disconnected from the circuit, it is easily seen that these limits are not easily obtained, unless, of course, some quick stopping device such as a solenoid brake is used on the motor shaft. The movement has to be accomplished by an electric motor driving the valve stem through reduction gearing and when the motor has driven the valve gate firmly, but not too tightly into its seat, it has to be disconnected by some form of limit switch that is also geared to the valve stem, and set to bear a definite relation to the position of the valve gate at all times. Of course, the armature and gears have considerable momentum and consequently the limit switch has to be set, to stop the motor, so that this overtravel will carry the gate tightly into the seat, or, in other words, energy stored up in the moving parts is relied upon to form a tight seat. The momentum

of the armature and gears after being disconnected from the circuit depends upon friction of the packing in the stuffing gland and of the moving parts, also the pressure on the valve disc, all of which are very uncertain quantities.

If a valve limit is set to close tightly without pressure on the disc, and with normal or loose stuffing box, it is easily seen that the limit may have to be changed for actual operating conditions, such as tight stuffing box and full pressure of the valve disc. In other words, the added friction would be so great as to allow of only a very small over-travel and consequently the valve would not close tightly. If a solid wedge type of gate valve is carried too tightly into its seat it soon upsets the bearing between the gate and the seat ring with the result that the valve cannot be made to close tightly. It is easily seen then that the apparatus required to fulfill these conditions has to be specially constructed.

The motor is chosen entirely in relation to its starting torque which must be very high in order to unseat a tight valve gate. It must run at a fairly low speed not exceeding say 750 rpm, firstly, on account of the gearing to the valve stem, and secondly, because of the armature momentum which must be kept to a minimum to enable a quick stop and to prevent jamming. The motor must be moisture proof for practically every application, not forgetting the extreme heat to which it will be subjected when operating on high pressure superheated lines. The temperature in which the motor is expected to operate often reaches 200 degrees F., so that special care must be given to the insulation to withstand this, otherwise deterioration will take place. The machine must be made to work in any position, the bearings being either of the ball or self-lubricating metaline type. Direct current machines are usually series or compound wound, the latter being used so as to prevent an excessive speed of the valve disc after it is unseated. When only alternating current is available polyphase motors are usually used on account of the poor starting characteristics of the single phase induction motor.

The limit switch has to be of the quick-break type capable of being immediately reset after breaking, so as to reverse the valve at any intermittent point and should be geared directly to the valve stem, so as not to be upset when the valve is operated by hand.

The controller may be a plain reverse switch or panel with indicating lights, to throw the motor across the line without any starting resistance.

These three units, well chosen in regard to their ability to operate together and applied to a valve constitute with the reduction gears a most reliable and efficient motor operation and quite the most perfect that has been developed.

This system has its limitations however. It cannot be standardized, while its inability to be applied to valves already in use without shutting down the line confines its application to new installations only. Direct and alternating current equipments of a given make necessitate different yokes, bonnet castings, and gear ratios to suit the motors, so that when a different make or speed of motor is used the castings and patterns have to be altered.

The motors have to be bolted directly to the yoke which on superheated lines is usually extremely hot, and such heat is transmitted through the field frame to the windings with damaging effect.

Different makes of limit switches and panels are used for short and long distance operation as well as for direct and alternating current, so that it is apparent that no standard can be adopted, especially as engineers frequently specify different makes of motors and controllers.

Trade Notes

The Chesapeake Iron Works of Baltimore, Md., manufacturers of the Chesapeake electric traveling cranes, have recently announced the opening of its New York office in the Woolworth Building. The office will be in charge of H. L. Mode.

Frey, Brassert & Co., Engineers, Chicago, have been retained by the Shelton Iron, Steel & Coal Co., Stoke-on-Trent, England, as consulting engineers in connection with blast furnace and rolling mill improvements.

The Electric Furnace Construction Company, Finance Building, Philadelphia, advises orders received for Greaves-Etchells electric furnaces from Lacheze et Fils, Dijon; and C. Markham & Co., Ltd., Chesterfield.

The Reading Iron Company have recently opened new district sales offices in Pittsburgh and Chicago. F. M. English has been appointed district sales manager in charge of the Pittsburgh office and R. A. Griffin, district sales manager in charge of the Chicago office. Craig Geddis has been appointed advertising manager and W. E. Dunham, production manager.

The industrial growth of Texas and Oklahoma, the ever increasing importance of their oil industries and the large demand made for modern machinery in this and other lines, has led the Ingersoll-Rand Company to establish a branch office to better serve the rapidly developing industries of this territory. The new office located in the Sam Houston Life Building, Dallas, Tex., will be in charge of R. H. Brown, Jr., as manager. Mr. Brown has heretofore been connected with the company's St. Louis office and has, for years, been in intimate touch with the Texas-Oklahoma territory.

H. W. Philbrook, formerly with the General Electric Company of Schenectady, has been appointed district manager of the Schutte & Koerting Co.'s New York Office, 50 Church street. The Schutte & Koertings Co. have lately issued a pamphlet entitled "Our Part in the War," and will take pleasure in mailing a copy to those applying for same.

The employees of the Westinghouse Electric & Manufacturing Co. have opened a coöperative store where employees can buy provisions at cost. The large storeroom or distribution depot has been secured at 709 Braddock avenue, East Pittsburgh, Pa., just opposite the general offices of the East Pittsburgh works. At this distribution depot employees can purchase standard commodities such as flour, ham, bacon, coffee and canned goods. Other standard commodities will be added from time to time as the demand becomes evident. This coöperation buying scheme is managed entirely by a committee of employees. The movement is endorsed by the management of the company which has placed with the committee its facilities

for placing orders with a standing credit where provisions can be purchased at the lowest cost. The coöperative buying will be done on the cash and carry basis, each person paying cash and carrying his purchase home. While this plan has just been announced by the committee, it is meeting with general approval and will probably result in quite a saving to the employees taking advantage of it.

The Hyatt Roller Bearing Company has received an order for steel mill bearings for the new three-high 28-inch billet mill to be installed by the Bethlehem Steel Company at its Saucon plant, Bethlehem, Pa. The mill is being built by the Morgan Engineering Company, Alliance, O.

The Link-Belt Company has made some new additions and extensions to their Belmont foundry at Indianapolis. The extension consists in completing furnace buildings Nos. 7 and 8 for the present only furnace No. 7, which is of 15-ton capacity, will be installed. Other machinery is being purchased such as rolling mills, sand blast and other foundry equipment. The building will be about 70 feet wide and 400 feet long.

Trade Publications

Schutte & Koerting Co., 1186 Thompson street, Philadelphia, announce that they have issued a revised 8-B catalog on "Stop, Stop Check and Emergency Valves."

The Cutler-Hammer Manufacturing Company of Milwaukee and New York, has prepared a number of standard 8½x11 descriptive booklets which illustrate and describe various types of C-H apparatus. A recent addition to this list of publications is known as Booklet "J" and is illustrative and descriptive of C-H Rectangular Magnets which are particularly adapted for efficient handling of regular shapes in steel and iron. The advantages of using a rectangular magnet over any other type of magnet for handling such material such as sheets, bars, billets, ingots, pipes, etc., is maximum lifting capacity for a given weight of magnet, resulting in economy in the price of the magnet, crane equipment, and current consumption, and besides, greater speed in handling the material. The booklet makes mention of a few typical applications where C-H rectangular magnets are handling ship plates, pipe, cold-rolled steel in coils, and other material. In one instance, one of the magnets has a record of unloading 50 tons of plate in 50 minutes from a railroad car to stock pile. Numerous illustrations show the magnets in use in several prominent plants. In some cases, two magnets are used on a spreader bar, especially where pipe or very long plates are lifted. The booklet describes the magnet construction, gives dimensions and other engineering data and tables of lifting capacities for various classes of material.

The Whiting Foundry Equipment Com-

pany, Harvey, Ill., has issued the following new bulletins: No. 146, "Cupolas and Cupola Charging Machines;" No. 147, "Ladles;" No. 148, "Core Oven Equipment;" No. 149, "Air Hoists and Elevators;" No. 150, "Side-blow Steel Converter."

"Electrical Operation of Gate Valves." is the title of a new 8½x11 booklet, being distributed by the Cutler-Hammer Manufacturing Company of Milwaukee and New York, which contains a reprint of an address given by Peter Payne Dean before the Metropolitan section of the American Society of Mechanical Engineers. Several illustrations and drawings have been added to aid the description of the Dean system of electrical control of gate valves. Primarily, the Dean control system consists of a totally inclosed water proof driving motor, reduction gears and limit trip mechanism combined into a single unit for the operation of the valve gate. The control of the valves is secured by means of our one or more remote control stations. The booklet makes mention of the desirability of having remotely controlled valves in power stations, waterworks, dry docks, refrigerating plants and oil refineries. It describes some of the standard valves and explains how these may be equipped for power operation with remote control without removing the valve or putting it out of service.

The Bailey Meter Company, Cleveland, O., has just issued bulletin No. 30 entitled "Fluid Meters for Low Pressure Gas and Air." The bulletin is well illustrated and describes the use and application of these meters.

The Esterline Company, Indianapolis, Ind., have issued a booklet entitled "Typical Graphic Records," presenting very interesting and instructive data on the use of graphic instruments in industrial plants.

The W. S. Rockwell Company, 50 Church street, New York, has put out a steel heat treatment chart with graphic charts and tables of interest to those connected with heat treatment problems. The chart is available to those who are desirous of securing a copy from the W. S. Rockwell Company.

The Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has just issued bulletin 1104 on "Steam Turbine Blading."

Bulletin 25 is the latest publication of the R. D. Nuttall Company covering the heat treatment of steel gears for industrial mining and electric railway purposes. Bulletin 26 is a publication devoted primarily to the application and use of the helical type of gearing for electric railway service. Much of the data given in this latter publication is of an educational nature and very interesting to users of gearing for industrial and mining purposes as well as electric railway operators since the features of helical gearing are such as to bring economy and very satisfactory operation on many different kinds of application.

The Blast Furnace and Steel Plant

Pittsburgh, November, 1919.



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